CENTRAL RICE RESEARCH INSTITUTE, CUTTACK

ANNUAL REPORT FOR THE YEAR 1957-58

N.S.P.
R.A.M.
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Agronomy Division

Season and crop condition.—There was an abnormal delay in the setting in of the South-West monsoon and even after onset, it remained quite weak throughout the year. Due to the scanty and irregularly distributed rainfall the sowing as well as transplanting of the crop was delayed. The total precipitation received during the period under report was 894·9 mm. (35·23″), which was 662·1 mm. (26·07″) below normal as is seen from the Table given below :—

TABLE I

Rainfall in 1957-58 as compared to the average rainfall of ten years 1946-47 to 1955-56

Monsoon	Month	Average rainfall		Rainfall in 1957-58		Deviation from the mean	
		mms.	inches	mms.	inches	mms.	inches
S. W. Monsoon	June	200·9	7·91	65·1	2·56	—135·8	—5·35
	July	274·1	10·79	192·4	7·58	— 81·7	— 3·22
	August	358·9	14·13	246·6	9·71	—112·3	— 4·42
	September	287·3	11·31	194·2	7·64	— 93·1	— 3·66
	TOTAL	1121·2	44·14	698·3	27·49	—422·9	—16·65
Post-Monsoon	October	216·4	8·52	49·9	1·96	—166·5	— 6·55
	November	72·6	2·86	0·0	0·00	— 72·6	— 2·86
	TOTAL	289·0	11·38	49·9	1·96	—239·1	— 9·41
Winter	December	10·9	0·43	0·0	0·00	— 10·9	— 0·43
	January	7·4	0·29	30·7	1·21	+ 23·3	+ 0·91
	February	20·8	0·82	74·1	2·92	+ 53·3	+ 2·10
	TOTAL	39·1	1·54	104·8	4·13	+ 65·7	+ 2·58
Pre-Monsoon	March	20·6	0·81	8·4	0·33	— 12·2	— 0·48
	April	23·6	0·93	1·8	0·07	— 21·8	— 0·86
	May	63·5	2·50	31·7	1·25	— 31·8	— 1·25
	TOTAL	107·7	4·24	41·9	1·65	— 65·8	— 2·59
	TOTAL FOR THE YEAR.	1557·0	61·30	894·9	35·23	—662·1	—26·07

At the Central Rice Research Institute Farm, rainfall was supplemented with irrigation and so the yields in general were not depressed.

There was a mild out-break of leaf roller and as a prophylactic measure, the crops were sprayed with Endrin. In the nursery, the seedlings were attacked by blast but no severe attack of any disease was noticed in the field.

I. Varietal Trials

The yield performance of 145 varieties, according to their duration was tested in seven varietal trials during the main crop season. Besides, 140 types were grown in observation plots to determine their suitability for the second crop season.

In an early varietal trial upto 100 days, 15 varieties were included with *Ch. 2* as the control. *DCA. 14* which gave an yield of 2228 lb. of grain per acre was found to be significantly superior to all the varieties included in the test. Variety *Ch. 2* gave an yield of 1817 lb. of grain per acre.

In 100 to 110 days duration trial, 16 varieties were tried against the standard *Benibhog*. *Ch. 48* which yielded 2302 lb. of grain per acre was the best variety. The yield of *Benibhog* was 1933 lb. per acre.

In 110 to 120 days duration trial, 20 varieties were compared against *BAM. 12*. Varieties *EHM. 7-13-43-95*, *EHM. 42-76-95-2*, *CH. 55*, *T. 6517*, *H. 755*, *EHF. 170-322-22-5* and *B. 76-1* gave significantly higher yields (3821 to 3516 lb. per acre) than the control which yielded 1639 lb. of grain per acre. The yield performance of rest of the varieties was as good as that of the control.

In 120 to 130 days duration trial, 24 varieties were compared against T. 635 as the standard. Ptb. 13 and EHM. 112-241-2-68 which yielded 2827 and 2731 lb. of grain per acre respectively were found to be significantly superior to the control which gave 2450 lb. of grain per acre.

In 130 to 150 days duration trial, 32 varieties were tried against the standards T. 1145 and T. 141. Varieties T. 61, T. 1879, T. 1850, BK. 6, T. 1233, T. 874-1-9-2, BHF. 535, T. 141-89, T. 141-84, T. 141, BHF. K-439, T. 588 and BHF. 345 which yielded from 3094 to 3739 lb. of grain per acre were found to be significantly superior to T. 1145 but statistically on the level of T. 141. The yield obtained from T. 1145 and T. 141 was 2549 and 3336 lb. of grain per acre respectively. Except T. 61 and the newly introduced cultures *viz.*, BHF. 535, BHF. K-439 and BHF. 345 which were introduced for the first time this year, the other varieties mentioned above gave higher yield than T. 1145 during last year also. Varieties T. 141-89 and T. 141-84 selections from the local popular variety T. 141 had been consistently giving higher yield than the parent during previous years, but during the current year the performance of these selections was as good as that of T. 141.

In a trial of varieties of over 170 days duration, 14 varieties were included with T. 4450 as the control. The highest yielding varieties *viz.*, Co. 19, Co. 2, SM. 11 and Ptb. 4 which produced 2841, 2710, 2699 and 2697 lb. of grain per acre respectively, were found to be significantly better than the control which yielded 2136 lb. of grain per acre. Co. 19 has been consistantly giving high yield for the last six years in this experiment.

The introductions from Japan do not grow and yield well in the main *Kharif* season but in the second crop season (December-April) some of the *japonica* introductions, Norin. 17 and Norin. 18 *etc.*, gave nearly 3,000 lb./acre in 1956-57 season. The performance of two promising *japonica* varieties *viz.*, Norin. 17 and Norin. 18 was compared this year also with two *indica* varieties Ptb. 10 and Mtu. 15 in the second crop season (December-April) under high fertility conditions (80 lb. N+30 lb. P_2O_5 per acre). Norin. 17 and Norin. 18 gave 2475 and 2085 lb. of grain per acre while Mtu. 15 and Ptb. 10 gave 2866

and 2088 lb. per acre respectively, but the yield differences were significant except between Ptb. 10 and Norin. 18. The Japanese varieties are more suitable for cultivation in the second crop season.

To determine the interaction between varieties and levels of fertilizer, 24 varieties of 150 to 160 days duration were grown at the levels of 0, 30, 60 and 90 lb. N per acre, the yields of which ranged from 2331 to 2431 lb. per acre. The varieties responded significantly to the application of N upto 60 lb. N per acre. There was no significant interaction between fertilizer levels and varieties.

In the second crop season, ten early varieties (eight *indicas* and two *japonicas*) were tried at the levels of 0, 40 and 80 lb. N per acre with and without 50 lb. $P_2 O_5$ per acre. All the varieties responded significantly to the application of fertilizers upto 80 lb. N level. CBII which gave an average yield of 2059 lb. of grain per acre was significantly superior to all other varieties except Mtu. 15 which yielded 1962 lb. per acre.

II. Manurial Trials

(a) *Efficiency of nitrogenous fertilizers for rice.*—The comparative efficiency of eight different nitrogenous fertilizers to rice at the rate of 20 and 40 lb. N per acre was tested for the fifth year in succession. The application of fertilizers was made at the time of transplanting. The yields obtained with various treatments are given in Table II below :—

Table II

Yield of paddy in lb. per acre for various forms of nitrogenous fertilizers

(Variety : T. 141)

Serial No.	Fertilizers	Levels of N/A		Mean
		20 lb.	40 lb.	
1.	Ammonium phosphate	2534	3324	2929
2.	Ammonium sulphate	2201	2774	2488
3.	Ammonium chloride	2250	2584	2417
4.	Urea	1998	2517	2258
5.	Ammonium sulphate-nitrate	2000	2367	2184
6.	Calcium ammonium-nitrate	1978	2244	2111
7.	Ammonium nitrate	1888	2167	2028
8.	Sodium nitrate	1543	1625	1584
9.	Control	..	..	1626
	Mean	2049	2450	

1. C. D. (0·05) per acre for form means 265
2. C. D. (0·05) per acre for level means 133
3. C. D. (0·05) per acre for treatment means 375

As seen from the Table above, this year, the highest response was obtained with ammonium phosphate which gave an increase of 908 and 1698 lb. of grain per acre with 20 and 40 lb. N level respectively and was significantly superior to the rest of the fertilizers. There was no significant difference between the yield increases obtained with ammonium sulphate, ammonium chloride and urea. As in previous years, the yield obtained with sodium nitrate was the poorest. All the fertilizers gave higher yield of grain per acre with the higher doses of nitrogen.

(b) *Placement and split application of ammonium sulphate and calcium ammonium nitrate.*—An experiment has been in progress since 1952-53 with a view to study the effect of placement of ammonium sulphate in split doses at different stages of plant growth on the crop yield. This year, apart from ammonium sulphate, calcium ammonium nitrate which has got half the quantity of available N in the form of ammonia and half in nitrate—was also included. As it is believed that at the advanced stage of the crop, rice prefers nitrate N over ammonical N. Calcium ammonium nitrate was applied later than ammonium sulphate in treatments where they are applied in combination.

Forty lb. N/A was applied in one, two and three instalments in different combinations to supply the fertilizer at planting, one month after planting and one month before flowering. In case of combination of both the fertilizers, first 20 lb. N was given in the form of ammonium sulphate and the remaining dose in the form of calcium ammonium nitrate. The experiment was conducted under low lying conditions with a long duration variety T. 1242. The results obtained are presented in Table III below :—

TABLE III

Yield of grain in lb. per acre under different split applications of fertilizers

(Variety : T. 1242)

Source of nitrogen	Single application		Split applications (40 lb. N/A in all)					Mean
			Two splits			Three splits		
	20 lb. N per acre	40 lb. N per acre	20—20 —0	20—0 —20	0—20 —20	20—10 —10	10—20 —10	
Ammonium sulphate	2370	2566	2921	2930	2938	3094	3279	2871
Calcium-ammonium-nitrate	2145	2457	2565	2633	2807	2842	2727	2596
Ammonium sulphate *plus* calcium ammonium nutrate.	..	..	2883	2871	3014	2973	2830	2914
Control	..	..	..	..	..	..	..	1931
Mean	2258	2512	2790	2811	2920	2970	2945	

1. C. D. (0·05) per acre for comparing individual means 295
2. C. D. (0·05) per acre for comparing doses means 155
3. C. D. (0·05) per acre for comparing form means 126

As seen from the above Table, combination of ammonium sulphate with calcium ammonium nitrate did not give significantly higher yield than ammonium sulphate applied alone and that the performance of calcium ammonium nitrate was significantly inferior to ammonium sulphate. Application of ammonium sulphate at different stages of plant growth did not show significant difference in yield but in case of calcium ammonium nitrate, the yields were increased with the later applications.

The results of the experiment have confirmed the findings of the previous years that with the fractional application, the efficiency of the fertilizer is increased as compared to the customary practice of broadcasting the entire quantity of fertilizer at a time.

(c) *Placement of different forms of nitrogenous fertilizers.*—The effects of placement and fractional application of four different forms of nitrogenous fertilizers *viz.*, ammonium sulphate, ammonium phosphate, ammonium chloride and urea were compared in an experiment. A long-duration variety BAM. 9 was used in the trial. The fertilizers were applied @ 30 lb. N per acre at different stages of the plant growth at planting, one month after planting and one month before flowering. The yields obtained with different treatments are given in Table IV below :—

TABLE IV

Yield of grain in lb. per acre

(Variety : BMA. 9)

Fertilizers	Method and times of application						Mean
	Surface 30—0—0	Sub-surface 30—0—0	Sub-surface 15—15—0	Sub-surface 15—0—15	Sub-surface 0—15—15	Sub-surface 15—7½—7½	
1. Ammonium sulphate .	1912	2168	2240	2134	2317	2371	2190
2. Ammonium phosphate .	2310	2350	2353	2499	2166	2384	2344
3. Ammonium chloride .	2119	2330	2587	2427	2544	2578	2431
4. Urea	2065	2260	2301	2326	2353	2382	2281
5. Control . . .	..	..	..	..	..	..	1541
Mean .	2102	2277	2370	2347	2345	2429	

1. C. D. (0·05) per acre for comparing individual means 414
2. C. D. (0·05) per acre for comparing form means 169
3. C. D. (0·05) per acre for comparing methods of application means . . . 207

The response obtained with ammonium chloride was significantly superior to that obtained over ammonium sulphate but not over the response obtained with urea and ammonium phosphate. Sub-surface and fractional application of the fertilizers gave significantly higher yield than the customary practice of broadcasting the fertilizer at the time of transplanting. Application of fertilizers in three splits gave higher yields than two splits but the differences were not statistically significant.

(d) *Response of rice to various types and levels of nitrogen in combination with phosphorous and potash.*—To study the response of an early variety Mtu. 15 to the different combinations of N, P and K in the second crop season, nitrogen was applied @ 0, 40 and 80 lb. N/A as ammonium sulphate, calcium ammonium nitrate and urea and phosphorus @ 0, 50 and 100 lb. P_2O_5/A as superphosphate

The treatments with potash @ 20, 40 and 60 lb. K_2O/A as Potassuim chloride in combination with 40 lb. N and 50 lb. P_2O_5/A were also included in the trial. The yield data are presented in Table V(a) and (b) below :—

TABLE V(a)

Yield of grain in lb. per acre.

Variety : Mtu. 15.

Fertilizers	Levels of N			Mean
	0	40 lb. N/A	80 lb. N/A	
1. Ammonium sulphate	1436	2226	2409	2024
2. Calcium ammonium nitrate . . .	1518	1925	2120	1854
3. Urea	1461	2246	2367	2025
Mean .	1472	2132	2299	

TABLE V(b)

Levels of P_2O_5	Levels of N			Mean
	0	40 lb. N/A	80 lb. N/A	
P_0	1420	2116	2388	1975
P_{50}	1523	2165	2300	1996
P_{100}	1473	2216	2208	1932
Mean .	1472	2132	2299	

1. C. D. (0·05) per acre for N means 96
2. C. D. (0·05) per acre for forms of fertilizer means 96

The yield of the crop increased significantly with the application of 40 lb N and 80 lb. N per acre. At 80 lb. N level, the yields increased significantly over that of 40 lb. N but the rate of response declined. The response obtained with ammonium sulphate and urea were significantly higher than the response obtained with calcium ammonium nitrate. Phosphorous and potash had no effect upon the yield of the crop.

(e) *Long-range manurial experiments.*—These experiments, as previously reported, are designed to investigate the cumulative effects of continuous application of various doses of fertilizers and manures on the productivity status of the soil.

(i) *Ammonium sulphate with and without compost and lime.*—This experiment has been in progress for the last ten years to study whether the continuous application of ammonium sulphate in varying doses has any deleterious effect on the soil productivity ; if so, whether it can be counteracted by the application of organic matter like compost and a soil ameliorant like lime. Ammonium sulphate at 0, 20 and 40 lb. N per acre is being applied every year on the same plots with and without 100 mds. of compost as basal dressing. Lime is applied once in three years @ 0, 4 and 8 cwt. lime per acre. The results obtained during the year are given in Table VI(a) and (b) below :—

TABLE VI(a)

Yield of grain in lb. per acre

(Variety : T. 1145)

Basal dressing of lime in cwt. per acre	Top dressing of ammonium sulphate N in lb./A						Mean
	No compost			Compost at 100 md./A			
	N_0	N_{20}	N_{40}	N_0	N_{20}	N_{40}	
L_0	1912	2677	3203	2642	3021	3136	2765
L_4	2150	2526	3051	2642	2316	2967	2692
L_8	1921	2640	3121	2581	3144	3041	2741
Mean	1994	2614	3125	2622	2994	3048	

TABLE VI(*b*).

Levels of N	Levels of compost.		Mean.
	C_0	C_{100}	
N_0	1994	2622	2308
N_{20}	2614	2994	2804
N_{40}	3125	3048	3087
Mean	2578	2888	

1. C. D. (0·05) per acre for compost means 89
2. C. D. (0·05) per acre for N and lime means 145
3. C. D. (0·05) per acre for N means at the same level of compost . . 181
4. C.D. (0·05) per acre for compost means at the same level of N . . 363

So far, no deleterious effect has been found in the plots to which ammonium sulphate alone has been applied continuously. Lime application either alone or in conjunction with N had no effect on yield of rice. 40 lb. N as ammonium sulphate has given the best yields.

(ii) *Ammonium sulphate with and without compost :*—This experiment was conducted for the 9th year in succession on the same site. The results are given in Table VII below.—

TABLE VII.

Yield of grain in lb. per acre. *Variety : T. 1145.*

Top dressing of ammonium sulphate nitrogen in lb./A.	Basal dressing of compost in mds./A.		Mean.
	C_0	C_{100}	
N_0	1958	2530	2244
N_{20}	2419	2700	2559
N_{40}	2996	2419	2708
N_{60}	2922	2321	2622
N_{80}	2864	2192	2528
Mean	2632	2432	

1. C.D. (0·05) per acre for comparing compost means 318
2. C.D. (0·05) per acre for comparing N means 225
3. C.D. (0·05) per acre for comparing N means at the same level of compost. 320
4. C.D. (0·05) per acre for comparing compost means at the same level of N. 574

As in previous years, the effect of ammonium sulphate was significant and also its interaction with basal dressing of compost. During this year, compost application has given a high response of 572 lb. per acre. In the case of ammonium sulphate applied alone there was a significant yield increase upto 40 lb. N/A., but when applied over a basal dressing of compost, the yield increased significantly only upto 20 lb. N/A.

The yield nitrogen relationships can be represented by the quadratic curves as given by the following equations :—

No compost—$Y=1927{\cdot}49+35{\cdot}74X-0{\cdot}30X^2$

Compost—$Y=2583{\cdot}00+0{\cdot}67X-0{\cdot}07X^2$

Where Y is the expected yield in lb. per acre and X, the N level. From the yield-N quadratic function, the estimated maximum yield of 2585 and 2992 lb. per acre was obtained with 5 lb. and 59 lb. N per acre in the form of ammonium sulphate applied over compost and no compost respectively.

To study the residual and cumulative effect of Ammonium sulphate and compost applied continuously for the last eight years, in the study mentioned above, each of the plots was divided into two and compost and Ammonium

sulphate were applied only to one half of the plot scheduled to receive the treatments. The results are presented in Table VIII. There was on residual effect in case of ammonium sulphate, but the crop in the plots where compost was applied in the previous years showed a cumulative effect and there was an increase in yield of 560 lb. of paddy per acre as compared to the *no compost* treatment and this difference was found to be statistically significant.

TABLE VIII.

Study of the cumulative effect of compost

Yield of grain in lb. per acre.

Level of N in lb./A.	Level of compost in mds./A.		Mean.
	C_0	C_{100}	
N_0	2058	2605	2332
N_{20}	1941	2560	2251
N_{40}	1976	2491	2234
N_{60}	1979	2510	2245
N_{80}	2053	2639	2346
Mean	2001	2561	

C. D. (0·05) per acre for compost means 370

(iii) *Residual effect of N, P and K alone and in combination with organimanures.*—To study the residual and cumulative effect of organics and inorganics, the N, P and K experiment, as reported during the previous years, was repeated but this year no application of manures and fertilizers was made. The yields obtained from different treatments are presented in Table IX(*a*.) and (*b*) below :—

TABLE IX(*a*).

Cumulative and residual effect of manures and fertilizers.

Yield of grain in lb./A. *Variety : T. 1145.*

Levels of N/A.	Organics @ 20 lb. N/A				Mean.
	Compost	Green Manure.	Ground-nut cake.	No manure.	
N_0	2468	2118	1985	1948	2130
N_{40}	2423	2154	2094	2104	2194
N_{80}	2390	2206	1997	1993	2147
Mean	2427	2159	2025	2015	

TABLE IX (*b*).

Levels of P_2O_5/A.	Levels of K_2O/A.			Mean.
	K_0	K_{30}	K_{60}	
P_0	2143	2153	2126	2141
P_{50}	2119	2084	2187	2130
P_{100}	2251	2211	2137	2200
Mean.	2171	2149	2150	..

1. C.D. (0·05) per acre for comparing organic means 332
2. C.D. (0·05) per acre for comparing N, P or K means 96

As seen from the above Table, the crop in the plots where compost was applied in the previous years, showed a cumulative effect and an increase of 412 lb. of grain per acre was obtained as compared to the *no compost* treatment and this difference was found statistically significant. However, groundnut cake, green manure, and different fertilizers showed no residual effect.

III. *Trials with green manure crops.*—Under the scheme for the improvement of green manure crops for rice, financed by the Indian Council of Agricultural Research, hundred green manure species were collected from India and abroad anf fifty species which appeared promising were studied in detail for production of green matter, suitability to different crop seasons, resistance to drought and water-logged conditions, seeding ability and nitrogen content of the crop.

As in the last year, *dhaincha*, sunnhemp, *Sesbania sericea*, cowpea, *mung Aeschynomene americana*, *Phaseolus semi-erectus* and *Sesbania speciosa*, when sown in May and June yielded about 6,000 lb. of green matter by July. For manuring of second season rice crop, *mung*, *Crotalaria usaramoensis*, *Crotalaria brownei* and *Sesbania sericea* were found suitable and gave nearly 4,000 lb. of green matter per acre at 8-week stage when grown between November to January. *Sesbania speciosa*, *Crotalaria usaramoensis* and *Crotalaria brownei* sown in the standing crop of rice in November-December gave nearly 10,000 lb. of succulent green matter per acre by the beginning of July.

As reported in the previous years, *Gliricidia maculata* was found very promising as the perennial road-side shrub. The 4-5 year-old plant gave an average yield of 30 lb. of leafy matter per plant in the months of July and another 15 lb. in January.

As in previous years, all the *Sesbania* species, *Aeschynomene americana*, *Phaseolus semi-erectus* and *Cassia tora* were found to resist water-logging considerably and under flooded conditions these crops gave nearly 4,000 lb. of green matter within eight weeks after sowing. Other varieties failed to establish under water-logged conditions.

The seed yield was satisfactory in most of the varieties and the seeding in different *Sesbania* spp. was comparatively better this year than in previous years. *Aeschynomene americana, Crotalaria* spp. and *Indigofera* spp. maintained their superiority with regard to seeding ability. As in previous years, the *C. brownei and C. usaramoensis* showed higher N content which is nearly double that of *dhaincha.* All the species of *Indigofera* and loppings from *Gliricidia maculata* also showed higher nitrogen content.

In an experiment to study the proper age and optimum time of burying green manure crop for paddy, repeated for the fifth time, it was found that eight-week-old green manure crop @5,000 lb. per acre buried at the time of transplanting and twelve-week-old crop incorporated eight weeks before planting gave yields of 3,349 and 3,313 lb. of grain per acre respectively. Control plot gave an yield of 2,825 lb. of grain per acre. It was therefore confirmed that eight-week-old crop of *dhaincha* which was succulent and tender could be buried even at the time of transplanting while twelve-week-old crop which was partially woody required to be buried eight weeks in advance of transplanting.

An investigation was carried out to confirm that the practice of sowing *dhaincha* with rice and incorporating it at the time of *beushening,* was beneficial to rice. In this study, *dhaincha* was incorporated in the soil 6 weeks after sowing at the time of *beushening.* An increase of 454 lb. of grain per acre was obtained in the green manured treatment over that of the control which gave 1,267 lb. of grain per acre. Application of 20 lb. N per acre as ammonium sulphate to *dhaincha* treatment resulted in an additional increase of 356 lb. per acre over the yield obtained when *dhaincha* alone was buried.

In another experiment, the relative efficiency of two common green manure crops, *dhaincha* and sunnhemp, was tested when applied in conjunction with inorganic fertilizers, *viz.*, phosphate, nitrogen and lime. Both *dhaincha* and sunnhemp gave identical yield responses whether grown *in situ* or brought from outside and the addition of P_2O_5 or lime did not result in any increased yield of the succeeding rice crop. The application of additional quantity of N as ammonium sulphate (30 lb. N) to green matter resulted in significant increase in yield over the control.

Investigations were continued to assess the relative manurial efficiency of 17 green manure crops grown *in situ* and brought from outside at 5,000 lb. of green matter per acre in both the cases. When grown *in situ, Crotalaria striata, Aeschynomene americana, Cassia leschenaultiana,* cowpea, *dhaincha, Sesbania speciosa* and *Phaseolus semi-erectus* increased the yield of rice crop by about 30 per cent over the control (no manure). When brought from outside and buried in, *Crotalaria striata, Tephrosia purpurea, Gliricidia maculata, Cassia leschenaultiana, Crotalaria brownei* and *Phaseolus semi-erectus* gave nearly 21 to 31 per cent. higher yields per acre than the control.

In an experiment to see whether *mung* crop grown for seed purposes was comparable in manurial value to *mung* crop buried at flowering no appreciable increase in yield of rice was obtained by incorporating *mung* either at flowering or after seeding. P_2O_5 applied to *mung* or rice did not result in any significant increase in yield.

The promising varieties of green manure crops were multiplied and a total of 430 lb. of seed of 12 promising varieties was supplied to different states for trial under different environmental conditions. The preliminary reports received from various places confirmed the superiority of *Aeschynomene americana*, *Crotalaria usaramoensis* and *Crotalaria brownei* etc., with regard to their adaptability to different soil conditions, production of green matter and seeding ability.

IV. *Cultural Trials* :—(*a*) *Crop sequence experiment.*—To determine the possibility of growing different legumes and cash crops in sequence with main-season rice crop, this experiment was carried out with nine rotational treatments in four replications. Six different crops besides *dalua* or *boro* crop of rice were grown during the preceding winter season to determine their suitability for inclusion in the sequence of cropping with rice and to study their effect on the succeeding rice crop. A short-duration variety, *Ptb. 10*, was grown during the main season so that the field might be available for sowing *rabi* crops in the month of November. But this year, in place of *Ptb. 10*, *T. 141* was grown in the main season in fallow/rice and rice/rice treatments, as there was enough time for this variety to grow without delaying the time of sowing of the subsidiary crops in these treatments. The different crop sequences tried and the yields obtained are presented in Table X(*a*) and (*b*) below :—

TABLE X(*a*).

Yield of paddy and of different subsidiary crops in lb./A.

Serial No.	Rotational treatments.	Preceding subsidiary crop. (Dec.-Apr.)	Succeeding rice crop (July-Dec.)
1	Fallow/rice (T. 141)	....	2866
2	Rice (Ptb. 10)/rice (T. 141)	1673	2846
3	Linseed (RR. 440)/green manure/rice (Ptb. 10).	190	2687
4	Berseem/rice (Ptb. 10)	9692*	2656
5	Green manure/rice (Ptb. 10)/green manure/ rice (Ptb. 10).	2288	2623
6	Gram (NP. 58)/rice (Ptb. 10).	224	2605
7	Groundnut (TMV. 2)/rice (Ptb. 10)	383	2560
8	Wheat (NP. 718)/rice (Ptb. 10).	189	2568
9	Cotton (P. 216F)/rice (Ptb. 10).	671†	2265
	C.D. (0·05) per acre for treatment means		383

* Berseem fodder. † Seed Cotton.

The rice crop following green manuring or leguminous crops gave practically the same yield which shows the *benefits of inclusion of leguminous crops in sequence with rice.* The rice yield obtained from cotton/rice treatment was the poorest. T. 141 in fallow/rice treatment gave the best results.

Double cropping of rice, particularly when green manuring was done in-between the two crops of paddy, gave quite encouraging results as is seen from Table X(*b*) below :—

TABLE X(*b*).

Double cropping of rice (Yield in lb./A).

Serial No.	Rotational treatment.	Preceding subsidiary crop.	Succeeding rice crop.	Total.
1.	Fallow/rice (T. 141).	..	2866	2866
2.	Rice (Ptb. 10)/rice (T. 141).	1673	2846	451
3.	Green manure/rice (Ptb. 10)/green manure/ rice (Ptb. 10).	2288	2623	4911

Thus, with the proper sequence of cropping a high yield of paddy can be obtained from the same land in a year, provided irrigation facilities are available.

(b) *Rotational Trial with Jute, Green Manure and Rice.*—During previous years, three crops of paddy were successfully grown on the same land under irrigated conditions by adjusting the dates of planting and proper selection of varieties. Since last year, jute was also grown (from April to July) instead of an early variety in order to determine the possibility of its introduction in the rotation. The details of planting and harvesting time and yield of the crops are give in Table XI below.

TABLE XI.

Details of planting and harvesting time and yield of the crops in lb. per acre.

Rotational crops.	Date of sowing.	Date of planting.	Date of harvest.	Yield in lb./A.	Total yield of paddy.
A Green manure.	12-12-56	..	4-4-57	1278	
Paddy (Ptb. 10).	9-3-57	6-4-57	13-7-57	1067	
Paddy (T. 141)	23-7-57	31-8-57	21-12-57	3012	4079
B Paddy (Ptb. 10)	22-12-56	5-2-57	30-4-57	1572	
Paddy (Ptb. 10).	9-3-57	5-5-57	29-8-57	900	
Paddy (T. 141)	23-7-57	31-8-57	21-12-57	2859	5331
C Paddy (Ptb. 10).	22-12-56	5-2-57	30-4-57	1933	
Green manure	2-5-57	..	28-8-57	15975	
Paddy (T. 141)	23-7-57	31-8-57	21-12-57	2375	4308
D Paddy (Ptb. 10)	22-12-56	5-2-57	30-4-57	1897	
Jute (JRC. 321)	2-5-57	..	29-8-57	1155*	
Paddy (T. 141).	23-7-57	31-8-57	21-12-57	2794	4691

* Yield of jute fibre.

Though three crops of paddy gave the highest total yield, the rotational treatment with jute gave the highest economic returns. Last year also, similar results were obtained.

(c) *Herbicides for weed control in rice fields.*—This experiment has been in progress for the last five years to evaluate the comparative efficiency of various selective herbicides for control of weeds in paddy field. The treatments included different formulations of herbicides belonging to M.C.P.A., 2, 4-D and 2,4,5 T group, customary hand-weeding and Japanese rotary weeder. The herbicides were sprayed six weeks after planting @ 2 lb. acid equivalent per acre in 100 gallons of water. The results obtained are given in Table XII below :

TABLE XII.

Yield of grain in lb. per acre under different weedicide treatments.

Serial No.	Treatments.	Yield in lb./A.	Percentage over the control.
1	Agroxone-3.	3528	122·3
2	Hand-weeding	3369	116·7
3	Phenoxylene-30.	3306	114·6
4	Ishihara 2,4-D.	3288	113·9
5	Japanese weeder.	3212	111·3
6	Cornox.	3202	111·0
7	Kathon M7.	3162	109·6
8	Fernoxone.	3143	108·9
9	Chloroxone.	3103	107·5
10	2,4,5-T.	3005	104·1
11	Shell 2,4-D.	2887	100·0
12	Control	2886	100·0

C. D. (0·05) per acre for treatment means 644

Agroxone-3 (a member of M.C.P.A. group) which gave the best results was found to be statistically on the level of the rest of the herbicides including 2,4,5-T, the performance of which used to be poor during previous years. Hand-weeding and Japanese weeders were also as effective as different her-

bicides and were not significantly superior to the control. During previous years, herbicides of M.C.P.A. group and hand-weeding produced significantly higher yield than the control. This year, the trend of effect of herbicides remained practically the same but the differences were not statistically significant.

(d) *Time of spraying herbicides in rice field.*—This experiment was conducted for the third year in succession to determine the suitable time of spraying herbicides for effectively controlling weeds in paddy field. Phenoxylene 30 (M.C.P.A.) and Chloroxone (2,4-D) were sprayed @ 2 lb. acid equivalent per acre, 2 weeks, 6 weeks and 10 weeks after planting. The experiment was conducted on low land-with a long duration variety *BAM. 9.* The results obtained are presented in Table XIII. below.

TABLE XIII.

Yield of grain in lb. per acre *Variety : BAM. 9.*

Serial No.	Treatment.	Weeks after planting.			Mean.
		2 weeks.	6 weeks.	10 weeks.	
1	Phenoxylene-30	2762	2754	2823	2780
2	Chloroxone	2921	2775	2678	2791
3	Hand-weeding	..	..	..	3056
4	Control	..	..	..	2986
Mean.		2842	2765	2751	

C.D. (0·05) per acre for comparing treatment means 237

As the experiment was carried out on low land, which was practically free from weeds, the different treatments did not show any effect upon the yield of the crop.

(e) *Different methods of paddy cultivation.*—To compare the relative efficiency of different methods of paddy cultivation, the Japanese, Chinese, Wave and Thackersey methods were tried against the recommended method of cultivation. Details of each method are given over leaf.

	Different methods				
	Wave method	Japanese method	Chinese method	Thackersey method	Recommended method
Nursery.	1. Salt water treatment to reject light seeds.	1. Salt water treatment to reject light seeds.	1. Drying seeds in the sun for two days.	1. Seeds to be soaked in water for 24 hours and sown on raised beds (3″ high).	1. Application of compost to nursery @ 8 tons per acre.
	2. Treating seeds with Agrosan.	2. Treating seeds with Agrosan.	2. Salt water treatment to reject light seeds.	2. 6″ tall seedlings to be used and treated with copper sulphate (1 oz. in 40 gallons of water).	2. Seeds to be treated with Agrosan.
	3. Sowing seeds @ 20 lb./A.	3. Sowing @ 15 lb. seed in 5 cents of land for an acre of field to be planted.	3. Soaking seeds in sodium-bi carbonate (48%) for two days.		3. Sowing @ 30 lb./A. for an acre of field to be planted.
	4. Preparing pulverised and compacted seed-beds.	4. Raising beds 4′ wide and 3″ high.	4. Seeds to be put in basket and covered with hay and watered twice a day with 80°F water temperature.		
	5. Seed-beds to be kept free from weeds.	5. Seed-bed manuring @ 1 md. compost and 1 lb. of ammonium sulphate for 100 sq. ft. nursery. Seeds to be covered with ¼″ of compost and ash.	5. Sowing the nursery after 2-3 days.		
	6. Seedlings to be sprayed with Perenox when ten days old.	6. Seed-beds to be kept free from weeds.	6. Sowing @ 30 lb./A.		
	7. Planting to be done at three leaf stage.		7. Manuring beds @ 1500 lb. of compost and 10 lb. amm. sulphate/A.		
			8. 5 to 11 lb. of amm. sulphate per acre to be applied 4-5 days before uprooting.		
			9. Using 25 day-old seedlings.		

Field preparation and manuring.	1. 15 to 20 cart loads of compost to be applied per acre.	1. 6,000 lbs. of green matter and 2½ tons of compost per acre.	1. Deep ploughing.	1. 20 lbs. N/A as organic manure.	1. 100 lbs. super to green manure.
	2. About 150 lbs. of Parry's rice fertilizer to be applied before mulching.	2. 100 lbs. of amm. sul. and 100 lbs. of superphosphate at planting time.	2. 3 tons of compost per acre.	2. Top dressings of amm. sul. in two splits of 15 lb. N each.	2. Green manure to supply nearly 20 lb. N/A to be incorporated.
		3. 100 lbs. of Amm. sul. and 100 lbs. of Super one month after planting.	3. 3 top dressings with 5 to 11 lbs. of amm. sul. per acre in the early stages.		3. Top dressings of amm. sul. in two splits of 15 lb. N/A. each.
Transplanting.	20″×6″. Planting to be done on either side of the rope so as to give a zig-zag appearance.	Line planting 10″×10″ with 3 to 4 seedlings per hole.	Line planting 6″×6″ single seedling.	1. Line planting 6″×6″ with single seedling.	Line planting 10″×6″ with 2-3 seedlings per hole.
				2. 2 to 3 weeks later, retransplanting is done by shifting the whole line to the next one and thus making the spacing 12″×6″ with 2 seedlings per hole.	
				3. Two to three weeks later, pruning is done leaving the plants 3″ from ground.	
Interculture	Two weeks after planting. first mulching is done with mulching hoe. Three mulchings to be given in all.	Three intercultures with Japanese weeder.	Three intercultures.	..	Three intercultures to be given.

A medium-duration variety, *T. 141* was grown and the crop condition was satisfactory, Yield data are given in Table XIV below :—

TABLE XIV.

Yield of grain in lb. per acre.

Variety T. 141

	Different Methods				
	Wave method	Japanese method	Chinese method	Thackersey method	Recommended method
Yield in lb. per acre	3081	2840	2900	2701	2354

C. D. (0·05) per acre for comparing method means 318

As seen from the Table above, there was no significant difference in yields obtained by different methods of paddy cultivation.

V. *Co-ordinated varietal trial.*—As a measure of co-ordination between the various Central Institutes, it has been decided to conduct trials simultaneously at different institutes to test the results under different climatic and soil conditions. During the year, trial with NP wheat varieties was conducted in co-operation with the Indian Agricultural Research Institute, New Delhi. Out of the ten NP wheat varieties, NP.761, which gave an yield of 791 lb. of grain per acre, was found to be the highest yielder.

BOTANY DIVISION

I. *Maintenance of Genetic Stocks.*

The collection of Genetic Stocks was increased by the addition of 175 varieties (49 received from various States in India and 126 from different countries). The collection now stands at 3536. During the year, in response to requests, 239 seed samples were sent out to 11 countries, *viz.* Argentina, Australia, British Guiana, Egypt, Belgian Congo, Cuba, French West Africa, Japan, Italy, Sierra Leone and Thailand.

The Institute also maintains a world collection of Genetic Stock of rice and is one of the five centres under the F. A. O. Scheme, for the maintenance and study of improved *indica* varieties received from different rice-growing countries. The Director, Central Rice Research Institute continued to be in charge of the overall supervision of the F. A. O. Scheme on the maintenance of Genetic Stocks at the various centres in the world.

Detailed morphological observations were recorded in the case of new accessions. Based on plant height, earbearing tillers, maturity, yield and other grain characters, 75 varieties from the Genetic Stocks have been selected for preliminary yield trials in 1958-59.

II. *Improving yield by :*

(a) *Introduction from Genetic Stock.*—Fifty-nine promising types brought ward from the Genetic Stock were grouped according to their duration l tested against the standard varieties in three preliminary yield trials. e results are presented below :—

(i) In 111-120 days trial, which had eighteen varieties, six varieties were found to be on par with one of the standards BAM.12 which gave 2308 lb. per acre but was inferior to the second standard B.76. These six varieties will be tested once again next year.

(ii) In 141-150 days trial, in which nineteen varieties were tested, Untung-588 from Indonesia, yielding 4071 lb. per acre, was found to be significantly superior over the standard, T. 141 which yielded 2830 lb. of grain. Two other varieties *viz.*, AC. 1060 and A. C. 2024 which gave 3205 lb. and 3075 lb. per acre along with six others which were comparable to the standard, have been selected for further test in the coming season.

(iii) In 151-160 days trial, in which twenty two varieties were tried against two standard varieties T. 90 and T. 1242, none were superior to both the standards ; however, eight varieties yielding between 1894 and 2161 lb. per acre were better than T.90, while AC. 3190 yielding 2161 lb. per acre was found to be on par with T. 1242 (2113 lb. per acre).

In a trial of five hill varieties from Uttar Pradesh, three upland types from enetic Stock and the standard type T. 141, were included. The yield of the rieties ranged from 888 to 1448 lb. per acre and none of them was signi- antly better than the standard.

(b) *Hybridization between* japonica *and* indica *rices.*—It has already been ated in the previous reports that two parallel projects of hybridization tween *japonica* and *indica* races of rice, one sponsored by the F. A. O. of the ited Nations, for the benefit of the South-East Asian countries and the her by the Indian Council of Agricultural Research, for the benefit of the dian States, were started at the Institute in 1951. The two projects ter- inated in March, 1956. Results of breeding on these projects are summarised low.

In these projects, 795 cultures were under study from F_3 to F_7 generations replicated progeny row trials. While the F_3 families were tested at four vels of soil fertility *viz.*, O N plus P_2O_5, 20 N plus P_2O_5, 40 N plus P_2O_5, and 60 plus 54 P_2O_5 per acre half the number of cultures was grown at normal rtility (40 lb. N as ammonium sulphate plus 36 lb. P_2O_5 as super phosphate) id half under high fertility (60 lb. N plus 54 lb. P_2O_5 per acre). While perphosphate was applied in one dose at the time of final puddling,

ammonium sulphate was applied in two split doses, first at final puddling an the second at flower initiation. Results are summarised below.

(i) *F_3 generation.*—Of the 70 cultures belonging to 24 cross-combina tions, grown under four levels of soil fertility under replicate Progeny Row Trial, 12 Cultures belonging to four cross-com binations *viz.* Zuiho × T. 1 (1 culture), Zuiho × Bhadas (7 cultures Zuiho × No. 22 (2 cultures), Fukoku × B. 76-1 (2 cultures) wer significantly superior over their respective *indica* parents, th increase varying from 44·4-158·2 per cent.

Taking each fertility level separately, there were 9, 11, 10 and 8 cultur in O N, 20N, 40N, and 60N levels respectively, which were significantl better than their respective *indica* parents. Results are given in Table XV

Four cultures *viz.*, Culture 25 and 28 from the cross Zuiho × Bhadas ar 60 and 61 from the cross Fukoku × B.76-1, were, significantly superior in yie over their *indica* parents in all the levels of fertility. Culture 60 gave a increasingly higher yield from O lb. N (2107 lb./acre) to 60 lb. N (5111 lb acre). Similarly, culture 28, (except at 20 lb. N) gave an increasingly high yield from O lb. N (2796 lb./acre) to 60 lb. N (3431 lb./acre).

Details of cultures tried in the different generations (F_4 to F_7) and al the number of superior cultures at different levels of fertility are given Table XVII.

Based on flowering duration, plant height and number of earbeari tillers per plant, 6857 field selections were made in the various generation of these, based on single plant yield and either grain characters, 1110 we finally selected for trial next year. Data are summarised in Table XVI.

(ii) *Bulk trials of promising* japonica-indica *hybrid cultures.*—Fo replicated bulk trials, one of F_6 cultures and 3 of F_7 cultures, we conducted at two levels of fertility, *viz.*, N. F. (40 lb. N plus lb. P_2O_5) and H.F. (60 lb. N plus 36 lb. P_2O_5) on a split-plot desig The results are presented in the Table XVII.

(c) *Breeding for upland conditions.*—The performance of 39 varieti selected from Early × High yield crosses, Jeypore Botanical Survey Collecti and Genetic Stocks were tested under purely rainfed conditions, agai B. 76-116 as the local standard. Out of these AC. 486 (Tr. 2 from Kera and B. 76-116 yielded 2467 lb. and 1862 lb. per acre respectively, but th was no significant difference between the two yields.

In the second trial under rain fed conditions with nine varieties, brou forward from last year's Preliminary Yield Trial, Ptb. 10 yielded 1721 lb. acre and was significantly superior to B. 76-116 which yielded 1394 lb. acre.

(d) *Breeding for resistance to blast and helminthosporium diseases.*—T project, as previously stated, is in progress in co-operation with the Mycolo (a) *Resistance to blast*—One hundred and sixty-eight cultures in F_3 to generation of the cross between Co. 13 (susceptible to blast) and Co. 25 (re tant to blast) were studied in four replicated randomized progeny row tr (F_4, F_5 F_6 and F_7 cultures). The cultures were flanked by Co. 13, the s ceptible parent, to provide enough inoculum for the natural spread of disease. All the cultures were grown under heavy-fertility conditions

TABLE XV

Yield data of significantly superior cultures, at different levels of fertility.

0 lb. N				20 lb. N				40 lb. N				60 lb. N			
Cross	Cult. No.	Yield/ acre (lb.)	Per cent over *indica* parent	Cross	Cult. No.	Yield/ acre (lb.)	Per cent over *indica* parent	Cross	Cult. No.	Yield/ acre (lb.)	Per cent over *indica* parent	Cross	Cult. No.	Yield/ acre (lb.)	Per cent over *indica* parent
												Zuiho × T.1. (796 lb.)	9	1889	237·3
Zuiho × T.1. (881 lb.)	9	1915	217·4												
Zuiho × Bhadas (1411 lb.)	25	3199	223·5	Zuiho × Bhadas (1334 lb.)	25	3219	241·2	Zuiho × Bhadas (1885 lb.)	25	2715	144·0	Zuiho × Bhadas (1925 lb.)	25	2766	143·7
	27	2756	192·5		27	2413	180·5		27	2893	158·8				
	28	2796	195·3		28	2228	166·9		28	3084	163·6		28	3431	178·2
	31	3643	254·5		31	2564	192·1		31	2796	148·3		..	..	..
	32	2332	162·9		32	2161	161·9		32	3421	181·5		..	..	..
	33	2675	186·9		33	2191	164·2								
					34	2530	189·5		34	2711	143·8		34	2786	144·7
Fukoku × B. 76-1 (1562 lb.)	60	2107	181·2	Fukoku × B. 76-1 (1582 lb.)	60	2994	189·1	Fukoku × B. 76-1 (1921 lb.)	60	4405	231·2	Fukoku × B. 76-1 (2534 lb.)	60	5111	201·5
	61	3165	202·5		61	3804	240·4		61	4477	219·2		61	3744	147·7
				Zuiho × No. 22 (575 lb.)	41	1734	301·7	Zuiho × No. No. 22 (800 lb.)	42	1945	243·0	Zuiho × No. 22 (649 lb.)	42	1855	285·7
				No. 22 × Zuiho (575 lb.)	43	1381	240·3	No. 22 × Zuiho (800 lb.)	43	1633	204·3	No. 22 × Zuiho (649 lb.)	43	2177	335·4

Figures in brackets indicate the acre yields of the indica parents.

Table XVI

Number of field selections and final selections carried forward with their average single plant yield. Number of cultures tried at different generations as well as those which were superior to indica *parent are also given.*

Serial No.	Filial Generation	No. of cultures tried	Total No. of field selection	No. of cultures significantly superior to *indica* parent		Number of final selections				Average (or range) single plant yield of selections			
				N. F.	H. F.	0 lb. N	20 lb. N	40 lb. N	60 lb. N	0 lb.	20 lb.	40 lb.	60 lb.
1	F_3	70	777			53	54	56	54	37·65	40·0	39·2	35·7
2	F_4	46 each in H.F. and N. F.	1472	17	15			117	122			35·4	41·7
3	F_5	141 in N.F. 138 in H.F.	1800	14	15			185	185			36-69	33-72
4	F_6	54 in N.F. 55 in H.F.	1800	2	17			54	54			30-50	30-59
5	F_7	118 in N.F. 125 in H.F.	1008	22	11			88	88			35-60	35-60

TABLE XVII

Number of cultures and indica *parents tried and significant cultures in N. F. and H. F. in the different bulk trials.*

Experiment	No. of cultures tried	No. of *indica* parents involved	No. of cultures significantly superior in N.F. to *indica* parent	No. of cultures significantly superior in H. F. to *indica* parent	Significantly superior cultures on the mean of two fertility levels to *indica* parent	Performance of cultures N.F. versus H.F.	Remarks
F_6 Bulk Trial	14	6	2	1	..	Differences between fertility levels not significant	Interaction of fertility level × culture not significant.
F_7 Bulk Trial I	19	7	3	1	2	Average performance better at N. F. than at H. F.	—
F_7 Bulk Trial II	11	6	3	1	3	Average yield in H. F. significantly better than in N.F.-2 cultures significantly superior in H. F. to N.F. and one culture in N. F. superior to H. F.	Differences between levels of fertility between cultures and the interaction cultures × fertility levels highly significant.
F_7 Bulk Trial III	12	5	1	1	2	Mean yield better under N. F. than under H. F.	Differences between levels of fertility and the interaction between cultures × fertility levels not significant.

20 lb. N as green manure plus 60 lb. N as ammonium sulphate in 3 split doses and 36 lb. P_2O_5 as superphosphate per acre. The nursery beds were also heavily manured at the rate of 40 lb. N as ammonium sulphate and compost per acre. Observations on the incidence of the disease were taken thrice in the seedling stage, the nursery beds were observed and diseased seedlings were discarded ; the second observation was made on the plant in the rapid tillering phase after planting and the third at the neck infection stage towards maturity. High-yielding and early-maturing selections were made only from the plants which were free from the disease at all stages.

(i) *F_3 generation.*—Thirty-four cultures were grown in an un-replicated trial. Nineteen cultures were superior to Co. 13. Out of 94 field selections, 29 which yielded above 40 gm. per plant and were free from the disease were finally carried for study next year.

(ii) *F_4 to F_7 generation.*—As already stated, 134 cultures were tested against Co. 13 in four replicated Progeny Row Trials. Results showed that, in all, 40 cultures yielding between 1596 lb. to 3186 lb. per acre were significantly superior over Co. 13, which yielded 857 and 1717 lb. per acre in different trials. Results of some of the outstanding cultures from each generation are presented in Table XVIII.

TABLE XVIII

Performance of some of the outstanding cultures from F_4, F_5, F_6 and F_7 generations in the Progeny Row Trials.

Filial Generation	Culture No.	Yield/ acre lb.	Per cent over Co. 13	Days to flower	Per cent infection (neck)
$F°_4$	14—24	3186	371·7	87	19·2
	8—50	2878	335·8	86	20·4
	8—49	2690	313·9	87	11·1
	214—17	2586	301·3	84	26·7
	410—5	1530	178·5	86	11·7
	Co. 13	857	100·0	78	
$F°_5$	545—9	2096	222·3	100	24·2
	384—11	2096	222·3	109	22·5
	286—80—3	2055	218·1	97	24·5
	562—1	2023	214·6	89	25·0
	124—82—7	1356	143·7	86	22·2
	Co. 13	943	100·0		
$F°_6$	556—26—8	2707	248·0	109	10·3
	561—50—22	2582	236·5	108	15·8
	556—26—3	2579	236·3	93	12·2
	558	2480	227·2	110	23·3
	556—26—26	2453	224·4	92	16·6
	610—94—97	1999	183·1	107	1·6
	Co. 13	1091	100·0	78	
$F°_7$	558—28—61—79	2708	107·1	97	4.1
	Co. 13	1717	100·0	78	
	562—31—56—3	2272	132·3	95	0 (NIL)*

*Retained on account of its complete resistance to blast.

It will be seen from the Table, that the cultures are not as early as Co. 13 (78 days to flower) ; most of them flower between 84 and 110 days, which is very much earlier than Co.25 the second parent, which takes 150 days to flower. Some of the cultures, though not as good yielders as others, have been selected on account of their high degree of resistance to blast, *e.g.*, Culture 410-5 from F_4 generation, Culture 518-13 and 124-82-7 from F_5 generation and Culture 610-94-47 from F_6 generation.

Based on resistance to disease, early maturity and good tillering habit, 715 field selections from F_3 to F_7 were made, and finally based on yield, seedling infection and other characters, 146 were finally carried forward for study next year. One culture from F_5 Progeny Row Trial, three F_5 cultures from F_6 Progeny Row Trial, 5 cultures from F_7 Progeny Row Trial were carried forward for bulk trial next year.

In the second crop season, 51 early-maturity cultures from F_4 to F_8 generations were raised in un-replicated trial against Co. 13 as the standard. Out of 48 field selections, 12 selections were finally carried for study in the next main crop season of 1958-59. Besides these, two cultures from F_8, were selected for Bulk Trial next season.

(iii) *Bulk Trials of promising F_5 and F_6 cultures from the cross Co. 13 × Co. 25.*—Twelve cultures (5 from F_5 and 7 from F_6) were tried against Co. 13 in a randomised replicated trial. All the cultures yielding 2122 to 1795 lb. per acre were superior over Co. 13(1137 to 1346 lb. per acre) by 13·0 to 54·0 per cent. All the 5 cultures from F_5 bulk Trial and the 7 cultures from F_6 bulk trial were carried forward for further trial next year.

(iv) *Resistance to Helminthosporium.*—Ten cultures from F_3 generation of the cross BAM. 10 × Co. 25, were raised in un-replicated trial against BAM. 10 as the control. Based on resistance to disease, tillering etc., 35 field selections were made and finally based on yield and other grain characters 10 selections were retained for further study next year.

(*e*) *Breeding for profuse tillering and high yield.*—As stated previously, a dwarf mutant characterised by thin narrow leaves, short stature, short thin, unbranched panicle and profuse tillering (90-105 tillers per plant) was observed in the variety T. 1222-12 in 1953-54. In order to combine the profuse tillering habit of this mutant in the cultivated varieties, crosses between the dwarf mutant (D-102-4) on the one hand and T. 1222-12 (N. 31-29) and AC-9(an early-maturing, low-tillering Chinese variety) on the other, were made in 1954-55 and their F_1 and F_2 generations studied in 1955-56 and 1956-57 respectively.

During 1957-58, 11F_3 cultures from the cross D. 102-4 × AC.9 and 12 F_3 cultures from the cross D. 102-4- × N. 31-29 were studied. Based on good tillering habit, early maturity and good yield, 42 selections from the cross D.102-4 × AC.9 were finally carried forward for further study. The number of ear-bearing tillers per plant in the selection ranged from 20-26 and single plant yield ranged between 30·5 to 57·8 gm. as against 16 E.B.T. per plant and single plant yield of 31·7 gm. for AC. 9. Similarly 56 selections from the cross D. 102-4 × N.31-29, were carried forward, for further study. The ear-bearing tillers of the selections ranged between 21·5 and 24 per plant and single plant yield ranged between 21·5 and 42·9 gm., as against 18·5 E.B.T. per plant and S. P. yield 31·7 gm. of N.31-29.

(*f*) *Breeding for quality and high yield.*—As reported previously, variety Ptb. 10, an early maturing high-yielding variety, is ideally suited for growing as an early *aus* crop as well as for growing in the second crop season, both under dry and irrigated conditions. This variety, is however, coarse-grained and red-kernelled. In order to combine high yield with good quality, crosses between Ptb. 10 on the one hand and N. 136 (fine-grained, white-kernelled low-yielding) and CH. 45 (medium grained, white-kernelled, moderate-yielding) varieties on the other were made in 1953, and the F_1 generation studied the same year, while F_2, F_3 and F_4 generations were studied in 1954, 1955 and 1956 respectively.

In the current year F_4 and F_5 generations of the crosses N. 136 × Ptb. 10 and reciprocal were under study. Eight cultures in the F_4 out of 28 cultures from the cross N. 136 × Ptb. 10 yielded 1845-2341 lb. per acre and of these, the highest yielding culture was significantly superior to Ptb. 10 (1835 lb. per acre). In the F_5 generation, two cultures out of 11 tested from the cross Ptb. 10 × No. 136, were superior to their parents. In the other cross, Ptb. 10 × CH.45, 16 cultures yielding between 2097 to 2721 lb. per acre were significantly superior to Ptb. 10. Fifty-eight selections out of 570 field selections in F_4 and 57 selections out of 1700 field selections in F_5, were retained for further study next year.

(g) *Breeding for resistance to lodging.*—(i) *Breeding* (1) *By Selection.*—This project is under study through a scheme financed by the Indian Council of Agricultural Research since September, 1956. Results of various experiments conducted under this project are summarised below.

In screening tests to select non-lodging, high-yielding varieties, fifteen varieties were tried against three high-yielding local standard varieties, in a randomised replicated varietal trial under low-lying and high-fertility (60 lb. N as ammonium sulphate and 54 lb. P_2O_5 as super phosphate per acre) conditions. Of these, W.24 was resistant to lodging and yielded 2771 lb./acre and was significantly superior to all the three standard varieties, BAM. 12, BAM. 9 and T. 141, which yielded 2361, 2267 and 1474 lb. per acre respectively.

In the second trial with four non-lodging Burmese varieties and two Indian varieties against the local standard T.141, the Indian varieties SLO. 13 and SLO. 15 yielded 3184 and 3384 lb. per acre respectively and were significantly superior by 57·6 and 65·5 per cent to the standard T. 141, which yielded 2020 lb. per acre. The Burmese varieties, though non-lodging, were later than the standard by 8-33 days and on par with it in yield.

Forty-four secondary selections (yielding at least 50 per cent more than the parents) from among the non-lodging varieties, were carried forward for trial next year against the original bulks.

(2) *Breeding non-lodging varieties through hybridization.—Study of F_1 generation.*—Thirty one F_1 plants from seven cross-combinations between five lodging varieties and five non-lodging varieties were raised under low lying and high fertility conditions. None of the hybrids lodged, whereas the lodging-susceptible parents lodged, thereby showing the dominance of resistance over susceptibility to lodging. The hybrids exhibited considerable hybrid vigour, with regard to plant height, ear-bearing tillers and yield. Eleven families were carried forward for further study.

Study of F_2 generation.—Twenty-one cross combinations, involving crosses between five improved Orissa varieties *viz.*, T.141, T.90, T.1145, and T. 1242 on one hand and seven non-lodging varieties *viz.*, AC. 517, AC. 1951, W.113, W. 130, W. 214, Nom-Dok-Mi and Puang Nak, on the other with 1-2 families in each were studied. Out of a total of 1257 field selections (basis same as in F_3), 270 selections, yielding at least 20 per cent more than the higher yielding parent, were finally carried forward for study next year.

Study of F_3 generation.—One hundred eighty-six selections from 12 cross combinations, comprising of crosses between four improved Orissa varieties *viz.*, T. 90, T.141, T.1242 and BAM. 9, one Chinese variety CH. 45 on the one hand and six non-lodging and generally low-yielding varieties, *viz.*, W.113, W.130, AC. 517, AC. 1951, Nam-Dok-Mi, and Puang Nak on the other, and 37 selections from 8 natural crosses were raised under low-lying and high fertility conditions. Based on plant height, number of ear-bearing tillers per pla nt non-lodging habit, flowering duration and heaviness of grain, 643 field selections were made, of which 168 selections yielding 22 to 90 gm. per plant with an average of 41·5 gm. per plant as compared to 24·2 gm. per plant of the parents (an increase of 71·5 per cent of selections over parents) were carried forward.

Similarly, out of a total of 497 field selections made in the F_3 of 8 natural crosses in five non-lodging varieties, 56 selections yielding on an average 39·5 gm. per plant as against 11·6 gm. per plant (average yield of parents) were carried forward for study next year.

(i) *Morphological studies.*—Sixteen non-lodging and 8 lodging varieties, were studied in detail for various characters like plant height, total tillers, ear-bearing tillers per plant, mean length of the longest root, mean width of the root zone concentration, shoot-root ratio, mean volume of roots, mean diameter of internode, density of culm at first, second and third internode, length of first, second, third and fourth internode, length of panicle, spikelet fertility per cent, and single plant yield. Density of the culm was determined from the weight per unit length (2 cm.) of the shade-dried internode. Data are presented in Table (appendix).

No absolute correlation could be read between any one of the characters enumerated above with susceptibility or resistance to lodging. However, a low shoot-root ratio, between 2·0 and 2·4 and a shorter length of 1st internode (3·25 cm.) compared to 3·63 cm. of the medium and late non-lodging varieties and 3·92 cm. of the lodging varieties, appear to go with resistance to lodging in the early varieties. In the medium and late varieties, a high mean culm density of 0·082 as against 0·056 of the lodging varieties and to some extent a short mean internode length (3·63 cm.) appeared to be associated for their non-lodging habit.

(ii) *Anatomical studies.*—Anatomical studies on one lodging (T. 1242) and one non-lodging (AC. 1951) variety, showed that as compared to a lodging variety, the non-lodging variety in general had a thick layer of sclerenchymatous tissue, smaller air cavities, a larger number of vascular bundles and abundance of starch grains in the cortical cells.

(iii) *Cultural practices in relation to lodging.*—Studies were carried out with one non-lodging variety AC. 1951 and a lodging variety BAM. 9, to see the effect of various cultural practices like spacing, fertility levels, date of sowing, pruning and ridging on lodging. In the first experiment, the two varieties were grown under three levels of soil fertility *viz.*, 0 lb. N+0 lb. P_2O_5, 30 lb. N+18 lb. P_2O_5 and 60 lb. N+ 36 lb. P_2O_5 per acre, and four spacings, *viz.*, 4″×4″, 8″×8″, 12″×12″ and 16″×16″ in a split-plot design with four replications.

Results showed that in the case of the lodging variety BAM. 9 lodging occurred 10 days after flowering where no fertilizers was applied, while at 30 lb. N and 60 lb. N, it occurred 10 and 17 days respectively before flowering. (2) Lodging occurred in all spacings but the extent of lodging in the initial stages was greater in 4″×4″ and 8″×8″ than in 12″×12″ and 16″×16″. (3) In most cases the lodging started from the middle and then spread to the periphery, the border plants being the last to lodge.

In the case of the non-lodging variety AC. 1951, lodging did not occur in any spacing and at any level of fertility right up to maturity ; however, at 60 lb. N towards late maturity stage, bending of plants was observed. In the case of AC. 1951 (non-lodging) there was a linear and significant increase in yield from 0 lb. N (3764 lb./acre) to 30 lb. N(4365 lb./acre) to 60 lb. N (4945 lb./acre). There was significant decrease in acre yield at 30 lb. N (3369 lb.) and 60 lb. N (2903 lb) as compared to 0 lb. N (3611 lb./acre) in the case of spacing variety BAM. 9, there were practically no differences in yield/acre for BAM. 9 but in the case of AC. 1951, 8″×8″ spacing (4782 lb./acre) was superior over 4″×4″ (4216 lb./acre), 12″×12″ (4360 lb./acre) and 16″×16″ (4074 lb./acre). In the second experiment, the same two varieties were grown under three dates of sowing at 17 days interval starting from 27th June,1957 and also subject to ridging *vs.* no ridging, and pruning *vs.* no pruning. The experiment was laid out in a split-plot design with four replications.

Results showed that (1) lodging occurred in the first and second sowings but did not occur in the third, due essentially to the poor growth, unfilled panicles and incidence of blast in this crop. (2) There was no lodging even in the weak-strawed variety BAM. 9 under ridged conditions (3) pruning delayed lodging, of the weak-strawed variety BAM. 9, till late maturity, both under ridged and unridged conditions, but it had a deleterious effect on grain yield which was significantly reduced both in BAM. 9 and AC. 1951 to the extent of 670 lb. in the former and 1378 lb. in the latter. (4) Between the varieties, AC. 1951, on the average yielded 3198 lb./ acre, which was significantly more than the yield of BAM. 9 (2342 lb./acre) by 36·0 per cent.

It can therefore be concluded that of the various cultural practices, ridging is by far the most effective method in preventing lodging, and thereby significantly increasing yield of a weak-strawed variety.

(iv) *Estimation of loss due to lodging.*—An experiment with 2 varieties BAM. 9 (lodging) and AC. 1951 (non-lodging), both of which were artificially lodged at 5 stages of plant growth *viz.*, 20 and 10 days before flowering, at flowering, and 10 and 20 days after flowering, and in one case left untouched as control and in another case propped with stakes to prevent natural lodging,

was laid in a split-plot design with four replications. The experiment was conducted under high-fertility and low-lying conditions. Data are presented in the Table XIX.

TABLE XIX

Effect of lodging at different stages of plant growth on yield of varieties Ac. 1951 (non-lodging) BAM. 9 (lodging)

Treatment	Yield per acre of AC. 1951 lb.	Per cent increase (+) or decrease (—) over AC. 1951	Yield per acre of BAM. 9 lb.	Per cent increase (+) or decrease (—) over BAM. 9	Per cent of AC. 1951 over BAM. 9	Treatment mean lb./acre	Per cent increase (+) or decrease (—) over control (unpropped)
Tr. 1 Control (no propping).	5,296	00·00	3,544	00·00	149·4	4,420	00·00
Tr. 2 Control (with propping)	5,944	(+)12·20	4,362	(+)23·1	136·2	5,153	(+)16·5
Tr. 3 Lodged 20 days before flowering.	1,188	(—)77·58	2,217	(—)37·5	53·2	1,703	(—)61·4
Tr. 4 Lodged 10 days before flowering.	2,496	(—)52·99	2,970	(—)16·2	84·1	2,733	(—)38·3
Tr. 5 Lodged at flowering.	3,399	(—)35·82	2,518	(—)29·0	135·4	2,958	(—)33·1
Tr. 6 Lodged 10 days after flowering.	4,391	(—)17·90	3,435	(—)3·1	127·5	3,913	(—)11·5
Tr. 7 Lodged 20 days after flowering.	5,180	(—)2·21	3,703	(+)4·5	139·8	4,442	(+)0·5
Variety mean	3,984·8		3,249·8		122·6		

1. C. D. at 5 per cent level to compare treatment means	555·4	S.E.	193·6
2. C. D. at 5 per cent level to compare treatment means within each variety.	780·9	S.E.	272·0
3. C. D. at 5 per cent level to compare variety means under each treatment.	1,079·6	S.E.	313·5

4. S. E. for variety means : 185·3

It will be noted that (1) between the varieties, on the mean of the whole experiment, AC. 1951 yielded 3984·8 lb./acre which was 22·6 per cent higher than the mean yield of BAM. 9(3249·8 lb./acre) though not significantly. (2) Between treatments, control with propping yielded 5153 lb./acre which was significantly higher than all other treatments. (3) In the case of the lodging variety BAM. 9, as compared to the control (unpropped), loss in yield to the extent of 37·5, 16·2, 29·2, 3·1 per cent and a slight increase of 4·5 per cent occurred under Trs. 3, 4, 5, 6 and 7 respectively. (4) In the case of the non-lodging variety AC. 1951, as compared to the control, loss to the extent of 77·6, 53·0, 35·8, 17·9 and 2·2 per cent occurred when plants lodged as in Trs. 3, 4, 5, 6 and 7 respectively. (5) On the mean of the two varieties as compared to the unpropped control there was decrease in yield to the extent of 61·4, 38·3, 33·1, 11·5 per cent in Trs. 3, 4, 5 and 6 and a slight increase of 0·5 per cent in Tr. 7. It would thus appear that lodging is most damaging when it occurs 20 days before flowering followed by that at 10 days before flowering, and that at flowering, and that at 10 days after flowering. There is no loss when lodging occurs 20 days after flowering. Since lodging generally occurs 7-10 days after flowering and some times at flowering, a loss of 11·5 and 33·1 per cent respectively would be quite substantial in reducing over-all yield.

(*h*) *Breeding technique: the value of modified bulk breeding in rice.* In 1953-54, from the F_2 generation of six cross combinations between GEB.24 and CO.25 as the *indica* parents and Norin 6, Norin 18, Norin 36, Asahi and Rikuu 132 as the *japonica* parents, a number of selection were collected from each cross, and the rest of the plants in each cross were bulk harvested and grown next year (1954-55) as F_3 bulk. In each cross, a number of early-maturing, heavy-tillering plants were selected in the field and on the basis of laboratory study, a number of the more promising ones were retained. These were once again bulked and sown next year as F_4 bulk. The process of selection and bulking as in F_3 was repeated in F_4 and F_5generations. In F_6 the cross-combination bulks were tested against their own *indica* parents as well as T.141 (local standard) in a randomised replicated bulk trial. Each cross-combination bulk consisted of the mixed produce from 10 selected plants. The analysis of variance showed the differences between bulks to be significant. Data on acre yield are presented in Table. XX

TABLE. XX.

Performance of F_6 japonica-indica *cross combinations.*

Cross combination or parent.	Yield/acre (lb.)	%Over *indica* bulk	Total duration days.
1. GEB.24×Norin 18.	3075	84·1	143
2. Co. 25×Norin 18.	3075	102·4	145
3. Co. 25×Norin 6.	3010	100·3	145
4. Co. 25×Rikuu. 132.	2920	97·3	146
5. Co. 25×Asahi.	2917	97·2	146
6. Co. 25×Norin 36.	2772	92·3	144
7. GEB. 24.	3653	100·0	147
8. Co. 25.	3001	100·0	181
9. T. 141 (control).	3662		142

It will be noted that two cross-combinations viz., Co.25× Norin 18 and Co.25× Norin 6 yielding 3075 and 3010 lb. per acre respectively are on par with the *indica* parent Co.25 (3001 lb./acre) and earlier than the latter by 31 days. The bulk of GEB.24× Norin 18 which yielded 3075 lb./acre was significantly inferior to the parent GEB.24.

A total of 1300 field selections were made and finally 10 best selections with mean S. P. yeild between 36·6 and 47·2 gm. from each cross-combination were retained for testing in Progeny Row Trial next year.

III. *Embryo culture:*

Observations on the artificial culture of 10 days old embryos of rice on White's and Randolph's nutrient media, indicated the superiority of the former over the latter, both with regard to the growth and survival of the seedlings.

IV. *Genetics :*

A number of investigations on the inheritance of dwarfism, morphological characters and occurrence of anthocyanin pigmentation and interrelationship of genes governing these characters, were carried out and are summarised below :

(a) Dwarfism .—Segregated in the ratio of 3 N : 1D in one cross GEB. 24×T.432 and 15 N : 1 D in another cross T. 1242× T. 432.

(b) Hairiness :—F_2 segregated into 3 :1, 9:7 and 162:94 of very hairy to ordinary hairy, both for hairiness of the hull and that of the leaf sheath. The two characters went together.

(c) Clustering of spikelets —In one cross, the F_2 segregated into 1:2:1 of normal cluster : intermediate cluster : single. In another cross between a super cluster and ordinary cluster, clustering was incompletely dominant and the F_2 gave a continuous segregation. In a third cross, clustering to non-clustering segregated into 15:1.

(d) Length of glume :—F_2 segregated into 3:1 and 54:10 of short glume : long glume.

(e) Beaked lemma palea :—Segregated into 9:7 and 3:1 of beaked : normal lemma-palea.

(f) Anthocyanin pigmentative character F_2 segregation of pigmented to non-pigmented is as follows :

(i) Leaf-sheath	27:37
(ii) Leaf-axil	3:1 and 9:7
(iii) Auricle	3:1, 15:49, 27:37 and 162:94
(iv) Ligule	27:37, 45:19, 108:48
(v) Junctura	9:7, 27:37
(vi) Junctura back	3:1, 9:7 and 162:94
(vii) Leaf blade	3:13, and 9:55
(viii) Tip and margin	3:1, 15:1, and 54:10
(ix) Pulvinus	45:19 and 61:3
(x) Septum	15:1, 57:7
(xi) Internode	3:1
(xii) Sterile glumes	3:1 and 54:10
(xiii) Apiculus	3:1 and 15:1
(xiv) Lema and palea	3:1 and 45:19

Study of the joint segregations showed that hairiness, glume length, dwarf character and clustering were inherited independently of the occurrence of pigment in various plant parts studied ; linkage, with a C.O. value of 36·04, 37·65 and 39·21 was established between beaked lemma-palea on one hand and pigment in leaf sheath, auricle and ligule on the other. Of the 74 cases of association between anthocyanin pigment in various parts of the plant, linkage was found responsible for this association in 56 cases and pleiotropy in the remaining 18. Strength of linkage was established in 26 cases out of 56, but could not be established in the remaining 30, due to lack of suitable formula for the unusual ratios involved in F_2 segregations.

V. *Plant Physiology :*

(a) *Effect of gibberellic acid treatment on certain dwarfs*.—The Central Rice Research Institute maintains a number of dwarf varieties, received from Japan, U. S. A., Madras and Bombay. In view of the stem elongating properties of gibberellic acid (G. A.) it was proposed to determine the effect of this substance on these dwarfs, with the object of classifying them, if possible, into G. A. responsive and G. A. non-responsive for further genetical studies. Consequently, a preliminary trial, using four dwarf varieties viz., Profuse Tillering Dwarf (CRRI Dwarf), Nejireva 803, Murasaki Koyabozu 836 and Mitsuryuto 832 (the latter three from Japan) was laid out in the second crop season of 1957-58. There were two major treatments viz. (1) soaking of seed in 1 PPM, 10 PPM and 100 PPM of G. A. (2) soaking the seed as in one, plus five weekly sprayings with the same three concentrations of G.A. Results showed that (1) except in Mitsuryuto 832, plant height in the other varieties increased in proportion to the concentration of the G.A. used being maximum at 100 PPM, however the maximum per cent increases over the control was variable in the three varieties being 46·5 per cent in CRRI dwarf, 15·8 per cent in Nijireba 803 and 16·4 per cent in Murasaki 836. There was no increase in plant height in Mitsuryuto 832.. None of dwarfs however reached the normal plant height under the treatments used in the trial. (2) Tillering in general increased in proportion to the concentration of GA. used. Between the four varieties, the increase was highest (39·8%) in Murasaki Koyabozu 836, followed by 38·5% in Nijireba 803, 16·2% in CRRI Dwarf and 10·2% in Mitsuryuto 832. (3) There were no appreciable differences in grain yield between the treated and the control. (4) Flowering was somewhat delayed by 1-5 days in the treated plants,but there was no constant relationship between the concentration of G. A. and the length of delay in flowering. (5) No association between G. A. treatment and spikelet sterility per cent could be established.

Results of the preliminary trial with G. A. do indicate the differential response of the four dwarfs tested to G. A. with regard to plant height, and some other characters.

(b) *Pattern of flower opening in rice.*—In any hybridization programme, it becomes necessary to know the right stage of the rice panicle when emasculation should be carried out to obtain the best results. For the best seed setting, generally only those spikelets are useful which are mature and expected to dehisce on that particular day. It is therefore very important to determine the day or days on which maximum spikelets dehisce, so as to effect the largest number of pollinations in a single day ; this becomes all the more important, when large-scale hybridization programmes like the *Japonica-indica* hybridization project are to be executed. A number of varieties from the Genetic Stocks, belonging to the early, medium and late-duration groups, as well as a number of wild species and inter-*indica* and inter species hybrids, were examined and the number of spikelets dehiscing each day in a panicle, were recorded. Summary data are presented in Table XXI.

It will be seen from Table XXI that (1) in early varieties, the flowering is over in 8 days and that the peak flowering period is the third day, but almost equal number of flowers open from 2nd to 5th day. In the medium and late varieties, the highest flower opening per cent occurs on 3rd. 4th and 5th day,

TABLE XXI.

Mean flower opening per cent per day in different classes of rice.

	Percentage spikelets opening each day												Total
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	
1. Eerly varieties	8·9	19·5	22·1	19·0	18·3	7·6	4·0	0·6					100·0
2. Medium varieties	2·0	10·6	17·8	27·5	22·2	12·0	5·6	2·0	0·1	0·2			100·0
3. Late varieties	2·2	13·6	20·9	21·3	17·9	11·1	7·6	1·1	3·2	1·1			100·0
4. Wild species	3·4	10·1	10·5	9·5	11·5	14·6	13·8	11·7	9·4	3·4	1·4	0·7	100·0
5.Inter varietal crosses F_1	4·2	28·9	33·4	20·9	9·9	2·1	1·2						100·0
6 Inter-species crosses F_1	3·4	9·2	12·6	15·6	18·0	17·0	12·4	5·2	5·1	1·1			

with the peak on 4th day and further, the flower opening is extended upto 10th day. In the wild species, the flowering is more uniform and evenly distributed from 2nd to 9th day (10·1 to 14·6 per cent) and it continues up to 12th day. In the intervarietal crosses, most of the flowering (82·2%) is concentrated on 3 days *i.e.*, 2nd, 3rd and 4th day, and the flowering is over by 7th day, while in the interspecies crosses, the flower opening follows practically the same pattern as in the wild species. The results thus indicate that variations in the pattern of flower opening exist in different groups of rices, and therefore, before embarking upon a big hybridization project, it is necessary to study the pattern of flower opening of the varieties to be crossed.

VI. Cytology.

(a) *Normal and variant cytology of rice.*—The collection of chromosome variants of rice consisted of an X-ray induced tertiary trisomic, four aneuploids (2N—24 x) derived from an autotriploid and 15 types of autotetraploids. The selfed progeny of the trisomic was studied for segregation for fertility and semisterility and this was found to be complex. Selections were made from the segregants for cytological study. In contrast, the selfed progeny of the aneuploids gave mostly fertile progeny showing that in the gametes, chromosome number in excess of 12 were rapidly eliminated. Six of the tetraploid types were used in an experiment on factors affecting their semisterility. Four homozygous (Seta, GEB. 24, Indrasail, and SR 26 B) and two hybrid types were grown in lines and given the following treatments. (1) Spraying with weak borax solution (2) Intensive manuring in the form of 2 grams of ammophos per plant in two doses as placed pellets (3) Manuring as combined with borax spraying (4) control with no spraying and only basis soil fertility. Mean spikelet sterility in the different treatments was estimated by taking samples of panicles and counting. This preliminary experiment showed that intensive manuring reduced the percentage of sterility in all the types while borax spraying increased the sterility in five cultures.

(b) *Inter relationship of Oryza species and the origin of cultivated rice.*—The tetraploid species *O.minuta* and *O.latifolia* have been included in the same section in the genus, because of resemblances in morphological characters. A study of interspecific hybrid between them supported this grouping. This hybrid was completely sterile, but the meiotic stage of division showed a prevalence of twelve bivalents together with 24 univalents. This type of chromosome pairing indicates that one genom is common to both the species. In the parental species, *O.minuta* has been established to be an allopolyploid forming 24 bivalents regularly at meiosis, and *O.latifolia* is probably an autopolyploid as two to four quadrivalents are frequent. From these data the following interpretation of genomic constitution in the species can be made. If the genom of *O.Officinalis* is designated as 0, 0, *O.latifolia* would be 0′ 0′ 0_2 0_2 while *O.minuta* would be 0′ 0′ G G. The G. genom is possibly that of *O. granulata* because some characteristics of *O. minuta* like shortness of ligule, smallness of spikelets, leniar articulate shape of leaves, and shade tolerant habit, could have been derived from the diploid *O. granulata*.

Genetical studies showed close similarity between the two cultivated species *O. sativa* and *O. glaberrima* in respect of two characters. The gene controlling extra growth of the glumes (sterile lemma) has been recorded to be a

simple, recessive to the gene for normal short size in the species *O. sativa*. A parallel single gene difference for glume length was observed in the hybrid progeny (F_1 and F_2) of a cross between two varieties of *O. glaberrimia* differing in glume length. In the genetics of hair development in the lemma also, the two species were similar. In *O. sativa* a basic gene controls hair development, and the degree of hairiness is inferred to be controlled by modifying factors. The recessive basic gene induces glabrousness in spikelets and a simple 3 : 1 ratio is obtained in the F_2.

In interspecific crosses between *O. sativa* and *O. glaberrima*, the F_1 is hairy when the *O. sativa* parent is hairy and glabrous when both the parents are glabrous. Due to sterility in F_1, the F_2 ratios were not secured.

Continuing last years work on the study of wild rices of Orissa, a few single plant progeny rows were grown from selections in natural wild rice population. These single plant progenies showed segregation for panicle characters and for semisterility. The progeny would be graded into those resembling *O. perennis*, those resembling cultivated rice and intermediates. The occurrence of this kind of segregation as well as the prevalence of semisterility supports the hypothesis of hybrid origin of *spontanea* rices. According to this hypothesis natural crossing as well as back crossing is taking place in nature where *O. perennis* grows in waterlogged areas adjacent to rice fields.

(c) *Evolution of cultivated rice*.—The genetics of response to variation in natural day lengths (photoperiod response) was found to be a useful line of investigation in tracing the differentiation of *indica* and *japonica* subspecies of rice. Some *japonica* varieties (e.g. Fukoku) are insensitive to photoperiods (day neutral) and will flower freely in 55 to 65 days from sowing in any season of the year. In contrast, the long-duration *indica* varieties are sensitive to photoperiods and flower only under short day lengths (season bound). The F_1 hybrids between the insensitive Fukoku and sensitive *indica* types were observed to be insensitive. The F_2 segregation confirmed this dominance relationship. Such a dominance of insensitivity is the reverse of what has been recorded in intra *indica* or intra *japonica* hybrids.

There is some evidence that response to photoperiod is modified by environmental factors. The *japonica* variety Zuiho has been observed to be season-bound, short-day plant in Japan, while at Cuttack, it flowers even under long-day conditions. This difference in flowering behaviour could be due to climatic differences between the two countries. If this inference is correct, the genes modifying photoperiod response are present in rice. The modifier system in the *japonicas* and the *indicas* must be inferred to be different and this difference must be correlated to the evolution of *japonica* rices from tropical types.

VIII. Jeypore Botanical Survey Scheme

(a) *Survey and collection of seeds*.—During 1955-56 parts of Jeypore tract, consisting of Malkangiri and Jeypore taluks of Koraput district (Orissa) were explored. Seed samples of 709 cultivated types from 183 villages, 22 wild types (*O. sativa* var. *fatua*) and one species (*O. granulata*) were collected. During 1956-57, parts of Nowrangpur, Koraput and Malkangiri taluks, and the adjoining areas of Kalahandi district of Orissa and Bastar district of

Madhya Pradesh were surveyed and 363 seed samples of cultivated types from 146 villages and 90 wild types (*O. sativa* var. *fatua*) from the adjoining forest areas were collected.

During the year under report (1957-58) parts of Rayaghada Bissam-Cuttack and Gunupur taluks and some villages such as Sathpur, Khasipur and Bijapur of Kalahandi bordering Koraput, which had not been surveyed earlier were explored. Extremely backward and uncivilized areas in remote hilly parts like Pottasing in Gunupur, Sunakhunti and Chandrapur villages in Bissam-Cuttack were also surveyed. It may be mentioned here that these areas are practically unapproachable during the major parts of the year. In these areas 162 seed samples of cultivated types (*O. sativa*) and 35 samples of wild types (*O. perennis*. *O. sativa* var. *fatua* and *O. granulata*) were collected from 102 villages and the adjoining forest and hilly tracts. Thus during the above three years, almost the entire tract has been covered and in all, 1234 samples of cultivated types and 147 samples of wild types were collected. (Table XXII(a).

TABLE XXII (A).

Total collection

	Cultivated	Wild	Total
1st year (1955-56)	709	22	731
2nd year (1956-57)	363	90	453
3rd year (1957-58)	162	35	197
Total .	1234	147	1381

TABLE. XXII (b).

Details of collection (1957-58)

Locality	Anchal	Varieties collected		Remarks
		Cultivated	Wild	
Gunupur, Gudari, Sirguda etc.	Gunupur	23	13	
Rayaghada, Kumbhikota, Gumma etc.	Rayaghada	7	2	
Bissam-Cuttack, Chandrapur Hanumanthpur	Bissam-Cuttack	21	6	*O. perennis* 9 *O. sativa* var *fatua* 25 *O. granulata* 1
Amdodala	Do.	29	2	
Kalyansingpur	Rayaghada	52	9	
Borigumma	Borigumma	14	1	
Sathpur, Khasipur and other villages	Kalahandi	16	2	
	Total .	162	35	

The collection exhibits a wide range of genetic variability and is described elsewhere in the report. The samples are grown in field during the main crop season for maintenance and study. Detailed study of the botanical and agronomical characters is being undertaken to evaluate their usefulness as breeding material and to eliminate synonyms.

(*b*) *Botanical Studies.*—Seed characters like grain size, ripening colours of lemma and palea, size of sterile glumes, nature and colour of kernel, awn, etc. have been studied for the 3rd years' collection. In addition to these studies, flowering duration, 100 grain weight, volume of 1,000 grains grading of the grain, sterility per cent, plant yield and line-yield were recorded for the previous year's (i.e. 1956-57) collection, grown in observation plots at the Institute during the season.

The entire collection excepting that of the present year, has been classified durationwise, and separately transplanted into suitable plots and their botanical and agronomical characters were studied. Each sample was grown in three rows, consisting of a total of 45 plants, with a spacing of $12'' \times 9''$. Ammonium sulphate was applied at the rate of 200 lbs./acre 30 days after transplanting. For comparison, standard Orissa strains were also grown side by side with the cultures.

During the current year, some of the promising early-duration types have been selected for a preliminary trial. Some of the collections were found to have the round bold *japonica* type of grain and these will be tested for their response to high manurial levels.

(i) *Grain size*.—Dimensions of the grains collected during this year were measured with dial micrometer and have been classified. From each sample 10 random grains were measured for length, breadth and thickness. The entire collection has been classified into 5 classes according to their length, viz., very short (5.5—6·4 m.m.), short (6·5—7.4 m.m.), medium (7·5—8·4 m.m.), long (8·5 m.m.—9·4 m.m.) and very long (9·5 m.m. and above).

Accordingly, the whole collection includes 107 very short, 105 short, 590 medium, 376 long and 56 very long grained types.

The samples were classified for their breadth under the following three catergories, viz., narrow (1·9—2·2 m.m.), medium (2·3 m.m.—2·7 m.m.) and broad (2·8 m.m. and above).

According to this grouping the collection includes 76 narrow, 430 medium and 728 broad grained samples. A two way classification according to both breadth and length group, suggested by the Botany Committee is given in the Table XXIII.

TABLE XXIII.

Grain size in m.m.

Length of grain	Breadth of the grain			Total
	Narrow (1·9-2·2 m.m.)	Medium (2·3-2·7 m.m.)	Broad (2·8 and above m.m.	
Very short. (5·5—6·4 m.m.)	28	51	28	107
Short (6·5—7·4 m.m.)	9	30	66	105
Medium (7·5—8·4 m.m.)	21	211	358	590
Long (8·5—9·4 m.m.)	16	101	259	376
Very long (9·5 m.m. and above)	2	27	27	56
TOTAL	76	420	738	1,234

(ii) *Shape index.*—Data collected on the length-breadth ratio, and analysis of the same, on the assumption that length-breadth ratio more than 3 to be oblong or elongated, and length-breadth ratio less than 3 as oval, the present year's collection can be classified into 37 oblong or elongated and 125 oval grained samples. The entire three year's collection can be grouped into 432 oblong and 802 oval grained types.

(iii) *Glutinous types.*—Visual observation of the cut surfaces of the husked grains tested with iodine solution revealed that all the 162 seed samples collected during this year (1957-58) were non-glutinous. It may be mentioned in this connection that in the collections made in 1955-56, 2 glutinous and 2 semi-glutinous varieties have been recorded.

(iv) *Awn.*—Studies on this character of the grain indicated that there are 3 fully awned, 7 partially awned and 152 awnless types among the current year's collection. Together with previous two years' collection, there are 134 awned, 55 partially awned and 1045 awnless types. The degree of awning varied from long awns (3·8—6·0 c.m.) to awn tipped. The presence of awned types indicates the primitive nature of the varieties grown in these areas.

(v) *Colour of lemma and palea.*—The ripening colour of lemma and palea of the current year's collection was studied and classified according to the colour chart recommended by Ramiah and Hutchinson (1938) (quoted from 'Rice Breeding and Genetics' by K. Ramiah, I.C.A.R. Scientific Monograph No. 19). The ripening colour of lemma and palea present a wide range of colours consisting of white, straw or fawn, black and tawny with all types of intergrades. The data are presented in Table XXIV along with those of the previous years.

TABLE XXIV.

Showing the colour of lemma and palea at ripening (According to Ramiah 1953)

Year of collection	a_1	a_2	a_3	a_4	b	c	d	e	f	j	k	l	m	n	o	p	q	r	s	Inter grades	Total
1955-56	211	8	13	7	13	10	..	4	112	20	26	6	18	..	37	6	1	..	..	217	709
1956-57	111	10	2	9	14	13	4	3	16	25	5	3	20	2	17	3	..	1	1	104	363
1957-58	54	23	10	5	21	11	..	2	8	3	2	..	3	3	2	..	..	..	..	15	162
TOTAL	376	41	25	21	48	34	4	9	136	48	33	9	41	5	56	9	1	1	1	336	1,234

The lemma and palea colour in the young stage could be studied in 237 types of the collection made and is given in Table XXV.

TABLE XXV.

Lemma and Palea colour (Early stage)	Lemma and palea colour at ripening																						Total
	a_1	a_2	a_3	a_4	a_1/a_2	a_1/a_c	a_3/a_5	a_4/k_2	$a_4/1$	a_3/m with purple apiculus	b	c	b/c	f	j	k	j/k	l	m	n	o	p	q	
A	90	5	3	1	5	1	1	14	1	..	..	1	5	1	1	2	..	..	..	..	..	..	1	132
B	..	..	..	..	..	..	..	1	..	...	1	..	..	..	..	..	..	..	..	..	..	..	..	2
C	1	..	..	1	..	..	1	..	..	..	..	4	4	..	..	..	..	1	..	..	..	..	..	12
F	2	..	..	2	..	..	..	..	..	..	..	..	3	9	..	..	..	2	2	..	1	..	..	21
G	5	..	1	1	..	..	..	..	..	..	..	..	..	17	..	2	..	..	..	..	1	..	..	27
H	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	..	..	1
I	..	..	1	..	1	..	..	..	..	1	..	..	..	3	1	..	..	..	..	..	..	..	..	7
J	1	..	..	..	..	..	..	..	..	..	..	..	..	..	3	..	..	.	..	..	..	..	..	4
K	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	..	..	1
M	1	1	3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	6	..	..	..	..	..	11
O	..	..	1	..	..	..	..	..	..	..	..	..	..	..	1	..	..	..	..	..	3	1	..	6
P	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	3	..	3
TOTAL	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	227

In 10 of these colours, which come under the primary colour classes B, C. O and N of Hutchinson and Ramiah, the apiculus was purple pigmented; this would indicate the hybrid origin of these types. Table XXVI gives these colours.

Table XXVI.

(Showing the colour of lemma and palea at ripening—Some different combinations).

	Lemma and palea colour at ripening						
	a_3	b	b with purple piculus	o	p	N with purple apiculus	Total
Lemma and palea colour at early stage—							
B with purple apiculus	..	..	3	1	..	..	4
C with purple apiculus	1	1	..	..	..	..	2
O with purple apiculus	..	..	..	3	..	..	3
N with purple apiculus	..	..	..	..	..	1	1

(vi) *Sterile glumes.*—The length of the sterile glumes is an important specific character of the rice grain and has been used by some systematists for classifying rice into some sub-species such as *O·sativa* var. *grandiglumis*. Out of the 162 seed samples of the 1957-58 a single sample has sterile glumes as long as lemma and palea, 24 have sterile glumes one third of lemma and palea, 77 types one fourth and 58, one fifth of lemma and palea. It may be mentioned in this connection that during the previous two years, 5 types with sterile glumes as long as lemma and palea have been collected. Table XXVII shows the comparative lengths of the sterile glume to lemma and palea of the entire three years' collection.

Table XXVII.

Sterile glumes

Year of collection	As long as lemma and palea	⅓ the length of lemma and palea	⅓ of less of lemma and palea	Total
1955-56	3	4	703	709
1956-57	2	0	361	363
1957-58	1	0	161	162
Total	6	4	1,224	1,234

As indicated previously, the seed samples collected from Jeypore tract are grown and maintained at the Central Rice Research Institute, for perpetuation and study of the material. The 1072 seed samples collected during 1955-56 and 1956-57, were grown in the main crop season (July-December) of 1957. A complete study of the characters such as duration, weight of 1000 grains, volume of 1000 grains, grading of the grain, single plant yield, line-yield, sterility per cent, could be made for the previous two years' collection.

Study of the botanical characters such as height and habit of the plant, length and colour of the internodes, number of ear-bearing tillers, dimensions and colour of the leaf, length and exertion of the panicle and other floral characters have been made for 400 cultures and will be continued for the rest of the collection in the coming season.

(vii) *Duration.*—The most important of the physiological characters of the rice plant is the duration. A study of the duration of varieties collected from Jeypore tract revealed that the range of duration varies from 70-180 days, with varieties of all intermediate maturation periods between these two extremes. J. B. S. 1037 and 579 were found to be very early types, coming to maturity within 60-70 days. 1063 types of the first two year's collection were studied for the duration and presented in table XXVIII below :

TABLE XXVIII.

Duration.

Year of collection	Early (upto 120 days)	Medium (120-149 days)	Late (150 day and above)	Total
1955-56	22	175	512	709
1956-57	46	265	43	354
TOTAL	68	440	555	1,063

It may be seen that out of the previous two years' collection 68 are early, 40 medium and 555 late duration types.

(viii) *Grading of the grain.*—For grading of the grain of the varieties collected, the classification suggested by Vachhani, M. V., Butany, W. T., and Nair C.P.K. (1952) (Development of standard grades and marketing. A tentative commercial classification of rice—Paper submitted for I.R.C.) was adapted. This method of grading by Vachhani *et. al.* (1952) is based on the shape index (length-breadth ratio) and the volume of 1000 grains, and accordingly 7 groups are suggested. The volume was determined by the method of displacement using alcohol as the medium. The data on the grading of 340 samples of 1956-57 collection together with the data of 1955-56 are given in the Table XXIX.

Table XXIX

Grades of the grain.

Grade name	Shape index length-breadth ratio	Volume in C.C.s of 1000 grains	Remarks	No. of cultures		
				1955-56	1956-57	Total
1. Oval fine	Less than 3	Upto 16·5 c.cs.	Small slender grains	80	46	126
2. Oval medium	,,	16·6-21·0 c.cs.	Short plump grains	104	131	235
3. Oval bold	,,	21·1 and above	..	179	59	238
4. Elongated fine	More than 3	Upto 16·5 c.cs.	Long slender grains	101	56	157
5. Elongated medium	,,	16·6—21·0 c.cs.	..	90	40	130
6. Elongated bold	,,	21·1 and above	Long bold grains	59	10	69
7. Elongated and very fine	More than 4	Length more than 9 m.m.	Very long grains	3	8	11
			Total	616	350	966

Table XXX.

Showing the frequency of distribution of various morphological characters in the wild types collected.

	Length of grain					Breadth of grain			Shape Index		Awn			Length of sterile glume			Ripening colour of lemma & palea									Nature of kernel.	
	Very short	Short	Medium	long	Very long	Narrow	Medium	Broad	Oblong	Oval	Long Awn	Short Awn	Awn less	As long as lemma and palea	$\frac{1}{2}$ of lemma and palea	$\frac{1}{3}$ or less of lemma and palea	a_1	a_4	b	c	e	f	j	k	Inter grade	Glutinous	Non-Glutinous
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1955-56	—	2	17	3	—	9	3	10	11	11	18	2	2	—	—	22	1	4	1	—	1	5	—	9	1	—	22
O. granulata	1									1			1			1	1	1									1
1956-57	nil	1	36	38	2	nil	22	55	27	50	73	2	2	nil	nil	7	7	5	4	2	—	3	19	5	32	—	77

Wild varieties of rice or 'balungas'.—As has been already stated, 35 samples of wild rice have also been collected during the survey from the adjoining hilly and forest areas. These varieties, commonly called *balungas*, include *sativa* var *fatua O. perennis* and *O. granualata*. *O. perennis* types are characterised by their underground rhizomatous stem, prostrate habit and spreading tillers that are bent at nodes. The panicles are very loose and lax with a few. number of spikelets. The spikelets which shed at maturity bear long awns, which in most case are pigmented purple. *O. fatua* types are either erect or semi-erect with comparatively compact panicles but having in common with *O. perennis*, the shedding nature of the spikelets at maturity. The colour dimensions, awning and other characters of these wild rices were studied and are given in Table XXX. The study of the wild types revealed that there was a good amount of variability in the size and shape of the grains, the ripening colour of lemma and in awning.

Special features of the collection.—Special mention may be made here of a double-grained variety collected from the village, Rothali of Borigumma anchal, and a clustered variety from the village Bhoza of Rayaghada anchal. A wild variety of paddy having peculiarly long sterile glumes and short ligules was also collected. These plants were erect annuals attaining a height of nearly a metre, with broad showy flag leaves and long lax panicles. The tillers were bent at basal nodes, and had internodes ranging in length from 20-25 cms. Internodes were purple lined. The sheath and axil of the leaf and the septum were also pigmented purple. Auricles were white, conspicuous 0·5—0·8 cms long ; ligules were white, short and triangular 0·3—0·5 cms. long ; leaves were broadly lanceolate, 30-32·5 cms. in length and 1·5 –1·8 cms. in breadth, hairy and deep green. Panicles were well exerted, erect and loose (lax) varying in length from 21·8—26·2 cms. An important character of the panicle was the presence of spreading secondary branches ; spikelets were broadly oblong 7·8—8·00 m.m. long ; 2·0—2·5 mm. broad, with long awns that are pigmented purple, the pigmentation being deep at the distal end. A noteworthy feature of the spikelets was the long sterile lemma which sometimes exceeded the length of the spikelet ; spikelets hairy with deep purple apiculus ; nature of spikelets was hard, dull-brown and non-shattering. Grains non-glutinous and dirty-white. The plants resembled *O. glaberrima* (a West African cultivated species), in gross morphological features, but a close examination revealed, that the two differ in as many as eight important characters. It is crossed with *japonicas*, *O. glaberrima*, *O. granulata* and other varieties of cultivated and wild rices of this tract to trace its phylogenetic relationships.

CHEMISTRY DIVISION

I. Investigations in nutrient availability on water-logged soils and its relation to growth, yield and nutrient uptake by crop—

(*a*) Preliminary investigations on availability of nitrogen in water-logged soils with graded levels of applied nitrogen fertilizer and its relation to nitrogen uptake, crop growth and yield were undertaken during the main crop season. Rice variety T. 141 (medium duration) was grown on a clay loam soil, and nitrogen as ammonium sulphate, in graded levels of 0, 20, 40, 60, 80 and 100 kg/ha. was applied 25 days after planting. Ammonium nitrogen content of soil was determined at 15 and 30 days after

nitrogen application. Total nitrogen content of plant was also estimated at these and subsequent stages of growth. The results are given in Table XXXI.

TABLE XXXI.

NH_4-N content of soil and nitrogen content of plant with increasing nitrogen application.

Nitrogen applied Kg/ha.	NH4-N content of soil ppm. 15 days and 30 days		N% of plant		Yield kg/ha.	
	after fertilizer application	after fertilizer application	15 days after fert. application	30 days after fert. application	Grain	Straw
0	10	7	1·6	1·2	3272	2720
20	18	6	1·9	1·4	3749	3367
40	21	7	2·3	1·5	3747	3842
60	35	7	2·4	1·6	3525	4096
80	54	9	2·7	1·8	3584	4386
100	65	8	2·9	1·9	3424	4536

It is seen that the increase in level of nitrogen application is associated with increase in ammonium nitrogen content of soil upto a period of 15 days after fertilizer application. At 30 days period after fertilizer application there was no difference in ammonium nitrogen content of soil in the various treatments. Nitrogen content of plant, however, was more at higher nitrogen levels, even after 30 days of fertilizer application.

Highest yield increase of grain was obtained in plots showing ammonium nitrogen status of soil ranging from 18-23 ppm. about 15 days after fertilizer application. Ammonium nitrogen content of soil over 35 ppm. at this stage of growth was associated with lower grain and higher straw yield.

Maximum grain yield in the trial was obtained when plants had 2·0 per cent nitrogen content at 15 days and about 1·5 per cent at 30 days respectively after fertilizer application.

Data show that nitrogen content of plant may be a better criterion than the nitrogen content of soil, for determining the need or otherwise of nitrogen application to a growing crop for increasing yield. Project is being continued to workout correlation between nitrogen content of soil, percentage nitrogen in plant at different stages of growth and subsequent grain yield of crop.

(*b*) Thirty-four soil samples from different fields in A block of the farm area were collected and analysed for total N, organic carbon, total P_2O_5, pH mechanical analysis, base exchange capacity, etc. Work has been under-

taken to keep a record of fertility status or various fields on the farm area. Further samples from different locations were also collected during the year and the work is being continued.

(*c*) Soil samples from permanent manurial experiments of Agronomy Division were analysed.

216 samples from permanent lime experiment, pertaining to years 1949, 1953 and 1957 were analysed for exchangeable Ca,Mg, K and soil pH. Results show that upto 1953, with four years of cropping and application of lime every alternate year, there was no change in exchangeable bases of limed and unlimed plots. Results of 1957 study, after eight year of cropping and application of lime very alternate year, however, show a slight decrease (1-2 me percent) in the exchangeable Ca and Mg. of top soil, both in the limed and unlimed plots. The decrease in exchangeable Ca content was, however, slightly more marked in the unlimed plots than in the limed ones.

Soil samples during 1953 were examined both from 0-6″ and 6-12″depths. It was seen that exchangeable Ca and Mg were comparatively more at lower depth than in the top soil. Further studies on changes of exchangeable bases due to continuous lime application with and without ammonium sulphate are to be continued during 1959-60 to trace the movement of applied lime in the soil profile.

II. Investigations on nutrient assimilation of rice plant in relation to grain yield :—

(*a*) Studies on comparison of ammonium and nitrate fertilizer as a source of nitrogen for rice crop grown under solution culture were continued. As observed during the previous year, better growth of plant was obtained with a combination of two forms of nitrogen. Nitrate fertilizer like ammonium nitrate has, however, been found inferior to ammonium sulphate for increasing rice yields under soil culture. Experiment was, therefore, laid out during the second crop season tofind out suitable time of application of nitrate fertilizer to increase their efficiency.

(*b*) Comparision of *indica* (Ptb. 10) and *japonica* (Norin 17) varieties for rice with respect of *partial efficiency* of nitrogen uptake for increasing grain yield was undertaken under solution culture experiment during the second crop season. *Partial efficiency* of nitrogen uptake for production of grain is defined, as reported earlier (Annual Report, 1956-57) as increase in yield of grain for unit increase in nitrogen uptake. Partial efficiency of nitrogen uptake was de termined at 10, 25 and 60 ppm. of nitrogen, respectively.

The results showed that *indica* variety Ptb. 10 (110 days maturation period) had one stage of maximum partial efficiency of nitrogen, at 30-40 days after planting at all nitrogen levels. At high nitrogen level of 60 ppm., *indica* variety showed a negative nitrogen efficiency, (*i.e.*, there was decrease in grain yield for increase in unit nitrogen uptake) if nitrogen supply was continued after the flower initiation stage. In the case of *japonica* variety, Norin 17 (104 days maturation period), on the other hand, there were two stages of maximum partial efficiency of nitrogen, at 10 and 25 ppm. nitrogen supply. One stage occurred at early stage of growth at about ten days after

planting and the second stage occurred at about 40-50 days after planting, which corresponded to the ear-initiation stage of the variety. At high nitrogen supply of 60 ppm. nitrogen, however, *japonica* variety showed a single stage of maximum partial efficiency occurring about twenty days after planting. There was no indication of negative partial efficiency with *japonica* variety when high nitrogen supply was continued after ear-initiation stage, right upto maturity.

Results suggest that for a short-duration variety like Ptb. 10, nitrogen application,either basal at planting or about fifteen days after planting, may be adequate for increasing grain yield and that there may not be need for top-dressing at the pre-flowering stage. In the case of *japonica* variety (Norin 17) however, two periods of nitrogen application, one basal and other at pre-flowering stage, are indicated for increasing grain yield.

It may be pointed out that investigations continued last year (Annual Report, 1956-57) on partial efficiency of nitrogen uptake by a medium-duration variety T. 141(145 days) has shown that at 10 ppm. nitrogen supply, this variety had two stages of partial efficiency similar to the *japonica* variety, but occurring at about 30-40 days and 70-80 days respectively after planting.

(*c*) Investigations were undertaken under pot-culture conditions to compare nitrogen response and nutrient uptake by rice, grown on sandy loam, clay loam and clay soil respectively of Mahanadi alluvium. Trials were conducted on the same soil, with variety T. 141, both during the main cropping season and with variety Ptb. 10 during the second crop seasons. Nitrogen as sulphate of ammonia was used in the trials at 0, 500, 1000, 1500, and 2000 mg. N per pot containing 12·5 Kg. of soil. Observations were taken on yield, and nitrogen, phosphate and potash content of samples. Initial nitrogen content of soil and control yields of grain obtained on the above textural soil classes during the two seasons are given in Talbe XXXII.

TABLE XXXII.

Total nitrogen content of soil and control yield of grain obtained on Different textural soil classes.

Textural class	Total N % of soil at the start of experiment	Grain yield gm./pot	
		Main season T. 141	Second season Ptb. 10
Sandy loam	0·06	23	24
Clay loam	0·08	44	18
Clay	0·09	28	16

It is seen that highest grain yield during the first cropping season is obtained on clay loam soil. During second cropping of the same soils, however, the grain yield on clay loam and clay soils drops considerably, while that on sandy loam is not affected. Nitrogen response on these soils is shown in table XXXIII.

TABLE XXXIII.

Nitrogen response on different textural soil classes.

(Yield increase over control, gm./pot.)

Nitrogen level mg./pot	Sandy loam		Clay loam		Clay	
	1st crop	2nd crop	1st crop	2nd crop	1st crop	2nd crop
500	12	17	6	25	20	19
1000	33	25	23	32	38	29
1500	36	35	23	37	45	31
2000	39	37	*	47	45	39

* Pots severely attacked by white ants.

During the first cropping season, highest nitrogen response is obtained on clay soil. Nitrogen response on different textural classes is seen to vary and higher nitrogen level appears necessary for similar response on sandy loam soil than on clay soil. Response on clay loam is however comparatively less because of the high initial grain yield on this soil. During the second crop season on the same soil, however, nitrogen response on clay loam was higher because the soil fertility had deteriorated badly as seen from its 'no manure' yield given in Table II.

Data on nitrogen, phosphate and potash content of harvest samples showed that in all three textural classes, the percentage nitrogen, both in grain and straw, increased with nitrogen level during both cropping seasons. During the first crop season nitrogen content of crop grown on three classes, at corresponding nitrogen levels was also the same but during the second crop season nitrogen content of both grain and straw was comparatively higher at all nitrogen levels in the clay soil than in the other two textural classes.

During the 1st crop season, percentage of P_2O_5 in straw, increased slightly with increase in nitrogen level on clay loam and clay soil. During the second

crop season however, P_2O_5 content of straw decreased with increasing nitrogen level on sandy loam and clay soil. Percentage of P_2O_5 in grain was neither affected by nitrogen level nor by soil texture.

Percentage of K_2O in straw decreased with increase in nitrogen in both the crop seasons, but the decrease was rather sharp during the second crop season, particularly in sandy loam and clay loam soils. K_2O content of grain also decreased slightly with increase in nitrogen level on all three soil classes during both the crop seasons.

(*d*) Studies on growth and nutrient uptake in relation to yield of rice, were undertaken under field conditions on a clay soil during the main crop season. Trials were conducted with a late-duration variety, T. 1242 grown at graded levels of 0,20, 40 and 60 Kg./N per hactre as sulphate of ammonia with and without applicate of phosphate and potash, each at 30 kg/ha P_2O_5 and K_2O respectively. Growth observation and nitrogen, phosphate and potash content of plant was determined at periodical intervals. Results showed that :—

(1) In the initial stages of growth upto 60 days the percentage of nitrogen in plant increased with increase in level of nitrogen application.

(2) The highest value of nitrogen content in all treatments was reached at about 30 days after planting.

(3) The differences in the nitrogen content of plants grown at increasing nitrogen levels was marked only upto a period of 60 days after planting and that at later stages of growth, nitrogen content of plant was more or less the same in all treatments.

(4) Percentage of P_2O_5 in straw in all nitrogen treatments increased slightly upto flowering and decreased later.

(5) P_2O_5 content of grain, on the other hand, increased from flowering to maturity.

(6) There was no difference in the P_2O_5 content of plant grown at various nitrogen levels upto flowering stage but at maturity, P_2O_5 content of straw was low in no nitrogen teatments-irrespective of the fact whether phosphate was applied or not.

(7) P_2O_5 content of plants grown on phosphate applied plots was seen to be slightly higher than those grown on no phosphate, upto a period of 30 days after planting. This difference between treatments was however not observable at later stages of growth.

(8) Percentage of K_2O in the plant was not affected by nitrogen or phosphate application and was practically the same in all treatments upto 60 days after planting.

(9) Just prior to ear primordia formation, however, K_2O content of straw decreased. This decrease continued upto flowering stage, after which it again increased.

(10) Grain showed a higher K_2O content at milk stage than at maturity

Grain yield obtained with different treatments is shown in Table XXXIV.

TABLE : XXXIV.

Mean yield of grain Kg./ha.

—	Without P & K	With P	With K	With P & K	Mean
–0	2485	2197	2587	2403	2418 (100·0)
–20	2920	3212	2823	2988	2986 (123·5)
–40	3258	3584	3266	3202	3328 (137·6)
–60	3684	3781	3632	3686	6696 (152·8)
ean	3087	3194	3077	3070	

C. D. 5 per cent. for comparing Nitrogen mean 267 Kg.

It is seen that nitrogen application increased grain yield significantly upto) Kg/ha. Phosphate fertilizer, used alone or in combination had, however, no gnificant effect on grain yield but there was a tendency for the grain yield be higher when phosphate was applied in combination with nitrogen ferti- er Potash fertilizer used alone or in combination had, however, no effect 1 grain yield.

It may be inferred from the above that the soil was deficient in nitrogen ly and was well supplied with available phosphate and potash for plant owth. Availability of phosphate to plant as measured by plant uptake emed to increase with period of flooding, as the phosphate content of plant own on no phosphate plots increased after 30 days after planting and at this age and later was the same as in plants that had received phosphate fertilizer itially. The work is being continued during the next main crop season two different locations to confirm the results and also to work out desirable riods at which tissue tests will give reliable results for need or otherwise of rtilizer application to the growing crop.

(*e*) Investigations were undertaken to determine the utilization of nitrogen y rice crop from different nitrogenous fertilizers in relation to their efficiency r increasing yield. Experiments were conducted in pots on the same clay am soil during the main and second crop seasons with the varieties T. 1242 nd Ptb. 10 respectively. Nitrogen was used in the trial at 1000 mg. N per pot ontaining 20 Kg. of soil and nitrogen fertilizer was applied well mixed with et soil after flooding and puddling. Results are shown in Table XXXV.

Table XXXV.

Yield in gm./pot and utilization of applied nitrogen with different fertilizer applied basal at planting after puddling.

Fertilizer	Main crop (T. 1242)			Second crop (Ptb. 10)		
	Yield grain	gm./pot straw	Percentage fertilizer N utilized	Yield grain	gm./pot straw	Percentage fertilizer N utilized
Control	34	41	—	15	10	—
Compost	40	53	8·5	19	11	7·0
Ammonium Sulphate	64	104	53·0	64	40	67·3
Ammonium Chloride	58	99	45·5	59	35	61·8
Urea	42	70	26·8	53	33	57·9
Ammonium nitrate	37	62	14·4	41	29	34·2
Calcium Ammonium nitrate.	40	69	18·8	38	25	31·3

Data show that efficiency of fertilizers for increasing grain yield were in th order ammonium sulphate>ammonium chloride>urea>ammonium nitrate= calcium ammonium nitrate. Compost on same nitrogen basis appeare a very poor supplier of nitrogen for crop growth. Poor efficiency of nitrat fertilizers is seen to be due to low nitrogen utilization by the crop from thes fertilizers. It was earlier reported (Annual Report, 1953-54) that considerabl portion of nitrogen from ammonium nitrate is denitrified under flooded condi tions and is thus not available for crop utilization.

Utilization of nitrogen from all fertilizers is seen to increase during th second crop season, because of sharp drop in the inherent fertility of the soi in the pots after the main crop season. The crop therefore relies more o fertilizer nitrogen from the start.

During the second crop season, a separate study under pot conditions o utilization of nitrogen from ammonium and nitrate fertilizers in relation t their time of application was also undertaken. Fertilizers were given at th rate of 1000 mg. N/pot either basal at planting or 20 and 35 days respective ly after planting. Basal application of fertilizers in this trial was done wel mixed in semidry soil condition just prior to flooding. Later fertilizer applica tions were done with very little water on soil surface and soil was stirred t a depth of 1″-2″ after fertilizer application. Rice variety Ptb. 10 was use in this trial. Results are shown in Table XXXVI.

Table XXXVI.

Grain yield gm./pot and utilization of fertilizer nitrogen with respect t time of fertilizer application.

Control yield—22 gm./pot.

Fertilizer	Basal at planting		20 days after planting		35 days after planting		Mean grain yield
	Grain	per cent fertilizer N utilised	Grain	per cent fertilizer N utilized	Grain	per cent fertilizer N utilized	
Ammonium sulphate	56	60	46	56	33	52	45
Ammonium sulphate nitrate	55	55	46	46	40	56	47
urea	59	56	59	57	36	41	51
Ammonium nitrate	44	33	51	45	44	50	46
Calcium ammonium nitrate	46	36	43	40	42	48	45
Mean	52		49		39		

It may be seen that percentage of fertilizer nitrogen utilised by crop and efficiency of fertilizers for increasing grain yield is altered by time of application. The interaction fertilizer time of application is significant. It is seen that both ammonium sulphate and ammonium sulphate nitrate give lower response and utilization of fertilizer nitrogen with later application. Urea also gives low response when applied 35 days after planting. Utilization of fertilizer nitrogen with ammonium nitrate and calcium ammonium nitrate, however, increases with delay in application, but there is not much gain in grain yield, except with ammonium nitrate applied 20 days after planting.

Application of urea, basal and 20 days after planting, has given as good response in this trial as ammonium sulphate, basal applied. It may be mentioned that urea in this experiment was applied to soil prior to flooding and not in wet soil after flooding as done in trials under Table. Investigations on urea reported earlier (Annual Report 1956-57) have shown that application of urea in soils prior to flooding assures better availability of nitrogen for crop uptake.

ENTOMOLOGY DIVISION.

I. Varietal susceptibility investigations.

(a) *Gall fly—Pachydiplosis oryzae* (W.M.) Mani.—The study of relative susceptibility of the World Genetic Stock Collection of the Institute to gall fly was continued by examination of samples drawn at the peak period of the pest incidence during October. Two hundred and twenty-six varieties of 90-110 days duration were studied this year. Twenty-four varieties examined in the previous years were also included. The percentage of infested tillers ranged from 1·25 in the variety Ptb. 2 to 69·23 in T. 828. The varieties were classified according to the degree of susceptibility.

(b) *Stem borers—Schoenobius incertulas* Wlk., *Scirpophaga innotata* Wlk.,, *Chilotraea* (Proceras) *polychrysa* Meyer., *Sesamia inferens* Wlk.—In the study of the varietal susceptibility to stemborers, one hundred and twenty-seven *Kalua* varieties were examined at both the early seedling stage and the flowering stage by drawing samples. The percentage of infested tillers ranged from 8·91 in the variety M. 36-30 to 89·88 in the variety DCA. 22. The percentage of white earheads ranged from 0·00 in the varieties Mtu. 20, Mtu. 15, Ch. 62, V. 361 and DCA. 22 to 18·75 in the variety Ch. 47.

It was found that, in general, the infestation at the earhead stage was considerably high in the varieties in which the infestation at the early stage was low and *vice versa*. But the following varieties were found to have high infestation at both the stages.

Adt. 14, Ch. 47, T. 1534, HR. 19, T. 2407, Adt. 19, PLR. 2, Co. 9, $T_2$2390, CH. 51 and black *boro*.

II. Incidence of pests in relation to agronomic practices.

Studies on the seasonal abundance of pests were continued with the object of determining the factors favourable for the prevalence and abundance of pests and the relationship between the incidence of pests and the season, the time of planting and the age of the crop. In this experiment, 30 days old seedlings of two varieties *viz.*, Ch. 45, and DI. 4, were planted at fortnightly

intervals from July to March. Infestation by pests was estimated by examination of samples drawn from each planting when the crop was 60 and 90 days old and at the time of harvest. The results obtained this year are discussed below :—

(a) *Gall fly.*—The infestation by gall fly which was 2·51 per cent during August in the crop planted in July extended till the middle of February (0·4 per cent). The peak period of infestation was observed to be from the last week of October to the first week of December when the infestation was 44·07 per cent in the crop planted during September. In general, the infestation was the maximum in the crops transplanted from the middle of August till the middle of September and minimum in the crop transplanted from the middle of November and later. Infestation by gall fly was more in 90 day-old crop than in 60 day-old crop. The peak of natural parasitisation of the immature stages of gall fly was observed to be between the end of November and the middle of December when it was 96·81 per cent.

Catches of gall flies at light trap showed a steady increase in their number from the middle of September till the end of October after which there was a decline.

(b) *Stem borers.*—Studies on stem borer incidence indicated that the infestation commenced in the crop transplanted in the middle of August (1·76 per cent of dead hearts) and extended till the end of April during which time it was 15·00 per cent. The infestation in the early seedling stage reached the maximum during the middle of December (19·22 per cent) in the crop planted in the middle of October and again in the first week of March (35·55 per cent) in the crop planted in the first week January. Infestation in the earhead stage of the crop was observed in all the plantings done from the first week of November. A maximum of 24·09 per cent of white earheads was recorded in the planting done in the first week of January.

Catches of stem borer moths at light traps indicated their prevalence from the middle of September, 1957 till the end of April, 1958. There was a steady increase in the moth population till the middle of November which indicated the emergence of a brood. This brood infested the early seedling stage of the crop planted from the first week of October till the third week of November, resulting in 19·22 per cent of borer-attacked tillers in the crop planted in the third week of October. A second peak in the population of moths was noticed during the middle of March, 1958. This brood infested the earhead stage of the crop planted during the month of January, 1958 resulting in 24·09 per cent of white earheads. This brood also infested the seedlings of the crop planted in the middle of December and in the first week of January, resulting in 35·35 per cent of borer attacked tillers.

III. Insecticidal trial to control pests.

(a) *Efficacy of different insecticides* —(i) *Gall fly.*—The comparative efficacy of nine insecticides in controlling gall fly was investigated in a randomised replicated experiment with the variety GEB. 24. Sprayings in the

treatments were given for five times with the respective insecticides to synchronise with the prevalence of adult population in the fields. The efficacy of the different insecticides in reducing the infestation was found to be in the following descending order. Endrin (endo-endo-isomer of HEOD)—0·04 per cent ; Folidol E 605 EC (Ethyl parathion)—0·10 per cent ; Ekatox (Ethyl parathion) 0·10 per cent ; Gartolit 54 (DDT & Gamma HCH)—0·10 per cent ; Malathion (Methyl parathion)—0·14 per cent ; Ekatin (Thiometon)—0·10 per cent ; Basudin (Diazinon)—0·03 per cent ; Metasystox (Methyl parathion) —0·10 per cent ; and Dipterex (Ethyl parathion)—0·10 per cent.

(ii) *Steam borers.*—Similar insecticidal trials were conducted in *dalua* season to study their efficacy in controlling stem borer incidence in the variety Ptb.-10. Three sprayings were given with the respective insecticides according to the prevalence of moths in the fields. The efficacy of the insecticides in reducing the infestation by stem borers was in the following descending order : Endrin—0·04 per cent ; Folidol—0·10 per cent ; Basudin—0·03 per cent ; Dipterex—0·10 per cent ; Fosferno (Ethyl parathion)—0·10 per cent ; Metasystox—0·10 per cent and Malathion—0·14 per cent.

(b) *Efficacy of different methods of application of parathion (Folidol—E 605 Conc.) in the control of gall fly.*—Gall fly is prevalent generally throughout the *Sarad* crop season. In order to evolve an economic spray schedule for controlling gall fly effectively, an experiment was designed to determine the stage of the crop to be sprayed and the number of sprayings required.

The experiment was conducted with the variety GEB. 24 in a randomised block with four replications. The insecticide used was 0·08 per cent Parathion (Folidol E 605 Conc.). The crop was sprayed weekly at different growth phases after transplanting, *viz.*, 7 to 35 days, 21 to 49 days, 35 to 63 days, 56 to 84 days and 7 to 84 days. The infestation by gall fly was estimated by examining appropriate random samples each of 60 cm. $\times$ 60 cm. before and after the series of sprayings in each treatment. Random samples were uprooted and examined in all the treatments four times, *viz.*, before the commencement of the sprayings, a week after the last spraying, at the peak period of infestation and at the time of harvest. But, in the treatments T1 and T6, samples were uprooted for examination whenever samples were drawn in the treatments T_2, T_3, T_4 and T_5. Consequently, the total area sampled was 25·2 per cent, in the treatments T_1 and T_6, 14·4 per cent in the treatments T_3 and T_4 and 10·8 per cent in the treatments T_2 and T_5.

Details of the treatments and the results are given in the Table overleaf.

It might be seen from the Table that the infestation ranged from only 0·04 per cent to 2·15 per cent in the check (T_1) and from 0·00 per cent to 0·59 per cent in the treatment T_6.

The infestation reached a maximum of 2·15 per cent in the treatment T_1, during the month of October, while the infestation in the treatment T_6 was checked considerably, the maximum infestation being 0·59 per cent. It was indicated that spraying the crop five times at weekly intervals from the 21st day till the 49th day after transplanting was the most effective in reducing the gall fly incidence. The examination of the samples in all the treatments at the peak period of infestation indicated that the infestation was the lowest in the treatment T_3, amongst the treatments with five weekly sprayings (*i.e.*, T_2, T_3, T_4 and T_5). Spraying the crop at later stages was not effective

TABLE XXXVII.

Control of gall fly at different stages of crop.

	Treatments	Dates of observation												Percentage of grain bearing tillers at the time of harvest	Yield in Kg./Ha.
		Aug. 20, '57		Sept. 3, '57		Sept. 10, '57		Sept. 24, '57		Oct. 8, '57		Oct. 29, '57			
		No. of tillers per unit sampling area of 60cm. × 60cm.	Percentage gall fly attacked tillers.	No. of tillers per unit sampling area of 60 cm. × 60 cm.	Percentage of gall fly attacked tillers.	No. of tillers per unit sampling area of 60 cm. × 60 cm.	Percentage of gall fly attacked tillers.	No. of tillers per unit sampling area of 60 cm. × 60 cm.	Percentage of gall fly attacked tillers.	No. of tillers per unit sampling area of 60 cm. × 60 cm.	Percentage of gall fly attacked tillers.	No. of tillers per unit sampling area of 60 cm. × 60 cm.	Percentage of gall fly attacked tillers.		
T_1	Check	86·19	0·04	169·28	0·46	200·97	0·95	1193·56	1·81	168·56	2·15	138·91	1·98	86·50	4488·73
T_2	Five sprayings at weekly intervals commencing from 7 days after transplanting from Aug. 7 to Sept. 4 (*i.e.*, 37, 44, 51, 58 and 65 days crop.)	—	—	—	—	195·50	0·56	—	—	—	—	133·25	0·49	87·16	4258·56
T_3	Five sprayings at weekly intervals from 21 days after transplanting from Aug. 21 to Sept. 18 (*i.e.*, 51, 58, 65, 72 and 79 days crop.).	92·19	0·00	—	—	—	—	85·81	0·47	—	—	129·50	0·36	87·61	4482·51
T_4	Five sprayings at weekly intervals commencing from 35 days after transplanting from Sept. 4 to Oct. 2. (*i.e.*, 65, 72, 79, 86 and 93 days crop.).	—	—	175·47	0·30	—	—	—	—	156·69	1·97	131·63	0·62	88·12	4277·83
T_5	Five sprayings at weekly intervals commencing from 56 days after transplanting from Sept. 25 to Oct. 23 (*i.e.*, 86, 93, 100, 107 and 114 days crop.).	—	—	—	—	—	—	182·38	2·00	—	—	134·69	1·35	86·88	4172·12
T_6	Twelve sprayings at weekly intervals commencing from 7 days after transplanting from Aug. 7 to Oct. 23 (*i.e.*, 37, 44, 51, 65, 72, 79, 86, 93, 100, 107 and 114 days crop).	104·75	0·00	181·53	0·14	200·53	0·89	175·31	0·55	163·44	0·59	128·91	0·15	89·80	4990·75

reducing the infestation. A spraying schedule, by reducing the number of rayings during the vulnerable stage of the crop, *i.e.*, the active tillering ıase, is to be arrived at in the future programme.

The yield data were not strictly comparable between the treatments ; the area sampled was not the same, thus giving a bias in the yield figures. ut, a comparison of the yield between the treatments, T_1 and T_6, indicated ı increase of 11·8 per cent in T_6 over T_1. The sampling technique is being udied with a view to improve the same so that the yield in all the treatments ıay be comparable.

IV. Control of stem borers in a crop under high fertility.

It was reported in the previous year that the percentage of white earheads ue to stem borers was significantly more in rice crop grown under high evels of nitrogen and that the yield potential of such a crop could be ffectively increased by controlling this high degree of infestation. In order o find out this yield potential, an experiment was conducted with the ariety Ptb. 10, under high levels of nitrogen where the stem borer ıfestation was controlled by spraying. The treatments included in the xperiment and the results are given in the Table overleaf :

The stem borer infestation was estimated by examination of random amples at thirty days after transplanting and at the time of harvest.

It might be seen from the Table that the percentage of borer-attacked tillers ı the seedling stage was significantly less in the treatment manured and prayed (T_3) than either in the check (T_1) or in the treatment manured and nsprayed (T_2). No significant difference was observed between the treat- ıents T_1 and T_2. But, the number of tillers per unit sampling area was ignificantly more in the treatments manured and unsprayed (T_2) and manured nd sprayed (T_3) than in the check (T_1), the difference between the treatments T_2 and T_3 also being significant.

The percentage of white earheads was significantly more in both the ıanured treatments (T_2 and T_3) than in the check (T_1) and it was significantly ess in the treatment T_3 than in the treatment T_2. The number of earheads er unit sampling area was significantly more in both the manured treatments T_2) and (T_3) than in the check (T_1), though there was no significant difference etween the treatments T_2 and T_3.

The yield was significantly higher in both the manured treatments (T_2 nd T_3) than in the check (T_1), the difference between T_2 and T_3 also being ignificant. An increase in yield of 84·39 per cent was obtained by manuring lone, while the increase was 143·8 per cent in a crop grown under high-fertility nd protected against the infestation by stem borers. Thus, the yeild poten- ial of a crop grown under high levels of nitrogen could be increased by 70·39 er cent, if such a crop was protected from stem borer infestation.

V. Estimate of loss in yield due to pestss.

Stem borers.—The data collected from the treatments, manured and unsprayed (T_2) and the manured and sprayed (T_3) in the experiment IV above were utilized to estimate the loss caused by the stem borers. The regression function of plot yield on the estimated percentage of white earheads is given below.

Table XXXVIII

Control of stem borers in a crop under high fertility

	Treatments.	Mean number of Tillers at the seeding stage per unit sampling area of 50 cm. × 50 cm.	Mean percentage borer attacked tillers at the seedling stage Angular values (Actual values within brackets).	Mean number of ear-heads at harvest per unit sampling area of 50 cm. × 50 cm.	Mean percentage of white earheads at harvest Angular values. (Actual values within brackets)	Yield in Kg./ha.
T_1	Check (Unmanured and unsprayed)	28·42	22·55 (14·80)	30·23	17·38 (9·05)	971·35
T_2	Manured (basal dressing at the time of transplanting ammonium sulphate providing 106·49 Kg. N per hectare and superphosphate providing 40·35 Kg. P_2O_5 per hectare).	63·05	22·00 (14·23)	43·63	23·84 (16·43)	1791·08
T_3	Manured and sprayed (manured as in T_2 above and transplanted crop sprayed with 0·1 per cent parathion (Folidol E 605 Conc.) Six times till flowering).	59·32	17·52 (9·32)	46·05	21·02 (13·01)	2368·11
	C.D. (0·05)	2·95	2·66	6·44	2·46	328·56

Y=2299·93—14·957X where 'Y' is the expected yield in kilograms per hectare and 'x' is the percentage of white earheads per sampling basis. It might be seen from the above regression that for every unit per cent increase in the incidence as white earheads due to stem borers, the loss was 0·65 per cent which worked out to be 14·957 kilograms per hectare, within a specified range of 7·90 to 21·57 per cent of white earheads.

VI. Occurence and control of other field pests.

6·3 acres of experimental crop was sprayed periodically with Folidol 0·08 per cent or Endrin 0·04 per cent for the control of gall fly. *Gundhi* bug attack was noticed on medium and late-maturing monsoon crop in an area of 20 acres from middle of November to middle of December. The pest was effectively controlled by dusting 5 per cent BHC. 2·8 acres of summer crop was sprayed according to the brood emergence with Folidol 0·08 per cent or Endrin 0·04 per cent to control stem borers. Mealy bugs in potted plants were controlled by spraying folidol 0·08 per cent.

MYCOLOGY DIVISION.

I. Study and estimation of resistance to diseases in the field of the collection of types under genetic stock.

There was a severe outbreak of blast in the seed beds, but there was very little infection in the crop later in the season.

One thousand one hundred and seventy-three (1173) types under Genetic Stocks were observed to be susceptible to blast in the seedling stage and seventy seven (77) to Helminthosporiose.

Later observations in the post-transplanting and flowering stages were confined to early-duration types in the Genetic Stocks. It was found that 10 types were susceptible to blast and 130 types to Helminthosporiose at these stages.

In the World Genetic Stocks, out of five hundred and sixty-six (566) types observed, three hundred seventy-four (374) were found susceptible to blast, and four hundred eighty-five (485) types to helminthosporiose in the seed beds. In the post-transplanting stage, 12 types were susceptible to blast and 24 to helminthosporiose and 2 to leaf smut.

II. Helminthosporium disease

(a) *Tests of resistance of selected varieties under natural and artificial infection.*—Out of 24 types of early duration group selected last year and carried forward for further test this year, 13 were tested this year under artificial infection. No infection developed on any of these varieties. These varieties will be carried forward to field tests during the next year.

(b) *Co-ordinated trial of selected resistant varieties in different States of India.*—The Co-ordinated trial of varieties selected as resistant to *Helminthosporium* disease was conducted in some of the centres in West Bengal, Assam, Bihar, Kashmir, Himachal Pradesh and Kerala. The resistant varieties were free from infection.

(c) *Breeding for disease resistance.*—As mentioned earlier, F_3 progenies of crosses between BAM.10 (a variety resistant to *Helminthosporium* disease but susceptible to blast) and Co. 25 (resistant to blast but susceptible to

Helminthosporium disease) were studied during the year in co-operation with the Botany Division. Selections based on yield and disease resistance were carried forward.

III. Blast Disease

(a) *Artificial infection tests on early types in Genetic Stock for selection of resistant types.*—Two hundred and fifty-eight (258) early types under Genetic Stocks which were carried forward from the last year's trial were tested during this year under artificial infection in the seedling stage. Reaction of these varieties under natural infection in the seedbeds was also observed and as a result of the studies one hundred and thirty-one (131) varieties were eliminated as susceptible and the remaining 127 types are being carried forward for further tests.

(b) *Co-ordinated trial of selected resistant varieties in different States of India.*—A co-ordinated trial of 13 varieties resistant to blast was conducted in some of the centres in Kashmir, Kerala, Himachal Pradesh, West Bengal, Madras, Mysore, Andhra, Bombay, Orissa and Bihar. The performance of the varieties varied in different centres. The general pattern of reaction of the varieties in different research stations since 1955 has been more or less uniform with a few notable exceptions. BJ. 1, a short-duratoin type from Bengal has been consistently resistant in all centres except Kalimpong, Tripura, Kanke, and Mahabaleswar (under artificial infection) and Nagenhalli. S.67, a long-duration type from Mysore has been, on the other hand, resistant in all centres including the above high plateau or high elevation stations. The general reaction of other varieties is also presented in Table XXXIX.

(c) *International co-operative blast resistant trial.*—66 varieties (11 from Burma, 5 from Egypt, 9 from Indonesia, 10 from Japan, 7 from Malaya, 4 from Taiwan, 8 from U.S.A., 3 from Philippines and 9 Indian) were tested under field conditions. The varieties found resistant in the tests were :—

1. A.29-20 (Burma)
2. Nabatat Asmer (Egypt)
3. BJ.1 (India)
4. SM.6 ,,
5. SM.67 ,,
6. Co.4 ,,
7. Co.26 ,,
8. Bengawan (Indonesia)
9. Tjina ,,
10. Norin 17 (Japan)
11. Norin 22 ,,
12. Norin 1 ,,
13. Milek Kuening (Malaya)
14. Kwangfu 1 (Taiwan)
15. Chianongyo 280 (Taiwan)

TABLE XXXIX.

Showing general pattern of reaction of selected rice varieties at various Rice Research Stations in India.

Name of Varieties	Reaction at Cuttack	Reaction in all stations situated in plains.	Reaction at high elevations.					
			Kanke	Kalimpong	Mahabaleswar	Nagenhalle	Ponnampet	Jeypore
I. BJ.1.	R	R	S	S	S	R	MR	R
II. S.67	R	R	R	R	R	R	R	R
III. SM.6	MR-MS	MR-MS	S	S	S	S	S	R
SM.8								
SM. 9								
CP.6								
CP.9								
MTU.5	MS	MR-MS		MS	..... Susceptible			
S.624								
CH. 55								
H.755								
AKP.8	(Moderately susceptible neck infection).							
AKP. 9								

Key.—R = Resistant ' MR = Moderately Resistant ' MS = Moderately Susceptible ' S = Susceptible.

Table XL

Showing the list of resistant and susceptible varieties received from different countries which were tested at Cuttack under I.C.B.R. Trials and their reaction to blast under Cuttack conditions—1957-58.

Reaction of the varieties included in the first crop season (June—January 1957-58) based upon seedling observation in seed bed, field reaction in post-transplanting stage (leaf blast) and in flowering stage (neck infection).

Serial No.	Name of the variety		Reation at Cuttack
	A.—RESISTANT TYPES		
1	A. 28-8	Burma	S
2	A. 29-20	,,	R
3	B. 43-11	,,	S
4	B. 47-5	,,	S
5	C. 24-71	,,	S
6	C. 24-102	,,	S
7	C. 15-10*	,,	R
8	C. 34-1	,,	S
9	C. 28-16	,,	S
10	D. 402	,,	S
11	B. 24-92	,,	S
12	Nahada	Egypt	..
13	Agami Mount	,,	..
14	Giza-14	,,	..
15	BJ-1	India	R
16	SM-8	,,	S
17	SM-6	,,	R
18	S. 67	,,	R
19	AKP-8	,,	M.S.
20	AKP-9	,,	M.S.
21	Co. 4	,,	R
22	Co. 26	,,	R

Serial No.	Name of the variety		Reaction at Cuttack
23	Bengawan	Indonesia	R
24	Intan	,,	S
25	Salak	,,	S
26	Tjahaja	,,	S
27	Sigadis	,,	M.S.
28	Ramedja	,,	M.S.
29	Tjina	,,	R
30	Ishikarishiroke	Japan	M.R.
31	Fujisaka-5	,,	S
32	Norin-17	,,	R
33	Norin-22	,,	R
34	Kanto-51	,,	M.S.
35	Sensho	,,	S
36	Pi-1	,,	S
37	Reishiko	,,	M.S.
38	Toto	,,	M.S.
39	Millek-Kuerning	Malaya	R
40	Kantor	,,	S
41	Seriraja	,,	S
42	Mayangasa Gumpal	,,	S
43	Wag-Wag	Philippines	S
44	Raminad-3	,,	..
45	Kwangfu-1	Taiwan	R
46	Chianongyo-242	,,	S
47	Chianongyo-280	,,	R
48	Zenith	U.S	..
49	Lacrosse		..

Serial No.	Name of variety		Reaction at Cuttack
50	C. I. 9045	U.S.A.	..
51	C. I. 9075	,,	..
52	C. I. 9155	,,	..
53	C. I. 9249	,,	..
	B.—SUSCEPTIBLE TYPES		
1	Nabatat Asmer	Egypt	..
2	Sabaini	,,	..
3	Co. 13	India	S
4	Mas	Indonesia	S
5	Norin-1	Japan	R
6	Nachin-11	Malaya	S
7	Siam-29	,,	S
8	Serendahkuning	,,	S
9	Buenktan	Philippines	S
10	Thailand	,,	S
11	Kunshan wu shiang Keng	Taiwan	S
12	Caloro	U. S. A.	S
13	Fortuna	,,	S

* Only leaf infection was taken into account.

(d) *Breeding for disease resistance*.—As mentioned earlier in the section o Botany, F_3, F_4, F_5, F_6, F_7 and F_8 progenies of crosses between Co. 25, a long duration variety resistant to blast, and Co. 13, a short-duration variety highl susceptible to blast were studied during the year both in the main and secon crop seasons. Selections were made for short duration, blast resistance an yield.

(e) *Control of blast by fungicides*—(i) *Spraying Trials*.—The mercuri fungicides, Mema, Aretan, Ceresan and Fernide (Thiram) were used a spray chemicals to test their efficacy to control blast. The metallic mercur content of the mercurial fungicides were standardised at 0·195 lbs./acre i

100 gallons of water and Fernide (Thiram) was used at 5 lbs. per acre. Unsprayed plot swere kept as control. The short-duration variety, Co. 13, which is highly susceptible to blast was used in the experiment. Thirty-five day- old seedlings were planted on 8-8-57 and ammonium sulphate @ 40 lbs. N per acre was applied one month after transplanting. Three sprayings were given, one before and two after flowering. 100 gallons of spray fluid per acre was used for each spraying.

Observations on percentage of neck infection were taken from 4 random samples of 2·25 ft. ×2 ft. each for unit plot. The data on percentage of neck infection and yield are presented in Table XLI below :

TABLE XLI

Percentage of neck infection and mean acre yield obtained with different spraying treatments

Treatments	Mema	Aretan	Ceresan Wet	Fernide	Control	C.D.
Percentage of neck infection.	0·975	0·995	0·956	0·380	1·181	..
(Angular values)	(4·9)	(4·7)	(4·8)	(2·8)	(5·95)	2·69
Mean yield per acre in lbs.	1101	1079	1014	800	787	97·206

It may be seen from the Table that the level of neck infection was very low in all the plots, even the control having only 1·18 per cent (5·95 angular value). Mema, Aretan and "Ceresan wet" gave significantly higher yield than the control. Between Mema, Aretan and Ceresan, there was no significant difference. Fernide was not superior to control in respect of yield.

(ii) *Efficiency of low-volume spraying.*—The relative efficiency of low-volume spraying and normal spraying was investigated with the following treatments : (*a*) Normal-volume spraying (100 gallons of spray fluid per acre), (*b*) Low-volume spraying (20 gallons of spray fluid per acre), and the control. The plots were sprayed twice before flowering and once after flowering. The fungicide used was Coppesan (0·6 per cent). The variety Co. 13 (highly susceptible to blast) was used. The layout was a replicated randomised one having unit plot size of 93·0′×11·25′ with nine replications. Twelve samples of 2·25′×2·0′ were examined for the occurrence of neck infection at the time of harvest.

The data taken on percentage of neck infection and yield per acre in lbs. are given in Table XLII.

TABLE XLII

Mean acre yield and percentage of neck infection obtained in spraying Coppesan at different volumes

	Low Volume spraying	Normal Volume spraying	Control	C.D. at 0·5 per cent
Mean yield per acre in lbs.	1626·06	1867·87	1430·23	1327·92
Percentage of neck infection	6·95	3·15	7·82	4·05
(Angular values)	(15·01)	(10·05)	(15·65)	..

From the data given above the following conclusions may be made.

(*a*) The amount of neck infection was very low during the crop season (7·82 per cent in the control). The difference in percentage of neck infection between control and normal volume spraying was only significant.

(*b*) Normal-volume spraying recorded the highest yield and this was significantly superior to the yield obtained over the control, but not over low volume spraying : though the low-volume spraying was also associated with higher yield than the control, the difference was not significant.

(iii) *Dusting Trials.*—The organo-mercurial fungicides, Ceresan, Slaked Lime, and Agrosan were used as dusts to see their efficacy in controlling blast. The metallic mercury content was standardised at 0·06 lb. per acre for each application and their efficacy in checking neck infection was compared with that of Bordeaux Mixture (5-5-50) and the control which was neither sprayed nor dusted. The fungicides were applied twice, once before and once after flowering. The variety used was Co. 13 (very susceptible to blast).

The layout was randomised blocks with four replications and the area of unit plot was $128' \times 30'$. Observations on the incidence of neck infection were taken from 16 samples of $2·25' \times 2'$ each. The incidence of neck infection was very low, being 2·68 per cent in the control plot. The yield data and the neck infection observed in the different treatments are presented in Table XLIII.

TABLE XLIII

Mean acre yield and percentage of neck infection obtained with the different dustings

Treatment	Ceresan Dust	Agrosan Dust	Bordeaux Mixture spray	Control	C.D.
Mean yield per acre in lb.	1,425	1,237	889	862	276·26
Percentage of neck infection.	0·385	0·28	0·9725	2·68	..
Angular values	(2·81)	(2·58)	(5·42)	(8·96)	2·07

The data showed that both Ceresan and Agrosan were associated with nificantly lower neck infection and higher yield than Bordeaux mixture l control. Between Ceresan and Agrosan, there was no significant difference her in neck infection or yield.

(iv) *Estimation of loss in yield due to blast.*—The experiment was designed estimate the loss in yield of rice due to incidence of blast. The differential aying schedule was prepared to bring out differential level of infection, that extent of loss can be estimated with the increase in the incidence of disease.

Two varieties of early-duration rice were employed, one Co. 13 being ceptible to blast and another T. 6522 being resistant to the same. The gicide used was Coppesan (0·5 per cent). The spraying treatments were ried out at normal-volume rate of 100 gallons per acre. The fungicidal atments employed were: (A) Dipping of seedlings in Coppesan at trans- nting with two sprayings before flowering and two sprayings after flowering;) Dipping of seedlings in Coppesan at transplanting with two sprayings ore flowering; (C) Without dipping of seedlings in Coppesan at trans- nting but two sprayings after flowering and (D) Control, *i.e.*, no dipping seedlings in Coppesan and no spraying.

The experimental layout was a split plot with the varieties of rice in the in split and the fungicidal treatments in the second. There were four lications. The size of the unit plot used was 21·0′×12·75′. To estimate ection, observations were recorded in four sample plots of 2·25′×2·0′. The a taken on percentage of neck infection and yield per acre in lb. are given Table XLIV.

TABLE XLIV

Mean acre yield and angular values of percentage of neck infection obtained in different treatments of fungicide

Treatment	Variety of rice			
	Co. 13		T. 6522	
	Percentage of neck infection	Mean yield per acre	Percentage of neck infection	Mean yield per acre
Two leaf syrayings+ two neck rayings.	0·26 (2·87)	956·56	0·04 (0·54)	1986·46
Two leaf sprayings	1·98 (8·07)	946·94	0·68 (4·68)	1801·28
Two neck sprayings	0·64 (4·51)	1024·79	0·07 (1·03)	1973·83
Control	2·77 (9·45)	696·52	0·80 (4·95)	1986·46

Figures in brackets denote angular values.

Percentage of neck infection.

C.D. (·05) to compare variety means.	0·7
C.D. (·05) to compare treatment means.	1·1
C.D. (·05) to compare treatment means within a variety. . . .	1·6
C.D. (·05) to compare variety means within a treatment.	1·9

Yield per acre (in lb.).

C.D. (·05) to compare variety means.	95·6
C.D. (·05) to compare treatment means	100·3
C.D. (·05) to compare treatment means within a variety. . . .	198·4
C.D. (·05) to compare variety means within a treatment	224·8

The incidence of the disease was very low and so no significant correlat could be obtained between the percentage of neck infection and the yie It may also be noted that the injurious effect of copper has affected the yi of variety T. 6522.

In the case of the trials with the medium-and long-duration varieties rice, little or no disease incidence was noticed.

Statistics Division

The division devoted itself to the routine duties of helping the otl divisions in statistical analyses of experiments and interpretation of resu obtained therefrom. In addition to above, the division undertook the followi work.

1. *Discriminant Function Studies.*—Investigations were carried out the use of discriminant function technique based on yield, number of earhea number of grains per ear, grain weight, total tillers at flowering and pla height at harvest for section of progenies in F_3 generation. The resul indicated that discriminant score was not more efficient than the straig selection based on yield alone in the progenies studied. Among the yi components, number of earheads recorded the maximum weight in the disc minant function.

2. *Correlation Studies.*—In a medium-duration varietal trial with varieties, simple correlation coefficients between yield, number of earhea mean length of earhead and height of plant at harvest were calculated sepa tely for each variety. Significant correlations were obtained between yi and number of earheads in all the varieties, whereas, correlations betwe yield and mean length of earhead and between yield and height were n significant in all the varieties. Plant height was correlated with both numb of earheads and mean length of earhead. The magnitude of correlatio were different for different pairs of characters. The highest correlation v recorded between yield and number of earheads followed by yield and me length of earhead. The average correlations of yield with number of earhea mean length of earhead and height were respectively +0·801, +0·354 a +0·328. The heterogeneity of correlations was tested and it was fou

ıt there were significant differences among varieties as regards correlations tween number of earheads, and mean length of earhead and number of heads and plant height. Correlations between other pairs of characters l not indicate any heterogeneity among varieties.

The average partial correlation between yield and number of earheads ıs +0·822 and that between yield and mean length of earhead was +0·462. ıe average partial correlation between number of earheads and mean ear- ıgth was negative and the value was —0·394.

Multiple correlation coefficients were worked out and the values ranged ɔm 0·779 to 0·928 in the differernt varieties. Multiple regression equations yield on other plant characters were also worked out and the results showed at plant yield is increased by 0·72 gm. to 2·85 gm. and 0·54 gm. to 2·95 gm. unit increase in number of earheads and mean length of earhead respectively the different varieties.

The results of the above studies suggest that amongst the characters ıdied, the maximum contribution to yield is made by the number of earheads, llowed by mean length of earhead and least by plant height.

FARM DIVISION

I.—Multiplication of improved strains

A total quantity of 2582 maunds of improved strains of paddy was multi- ied during the year.

II.—Maximum potential experiment

As previously reported, this permanent experiment has been designed to termine the extent to which yield could be stepped up by adopting the ıproved methods of cultivation. In the same site of 4·93 acres, a green anure crop of *dhaincha* grown *in situ* (estimated to give about 5,000 lb. of een matter per acre) was buried in the soil a week before planting. Ammo- ıum sulphate at the rate of 100 lb. per acre was applied at the time of final ıddling and worked into the soil.

The strain, BAM-9, was planted in the first week of August. An average re yield of 3346 lb. was obtained as against 2713 lb.—the average of the evious years.

III.—Comparative efficiency of sowing practices

1. Transplanting on 7th August, 1957.
2. Dibble sown (dry) on 24th June, 1957.
3. Dibble sown in puddle on 6th August, 1957.

The results of the experiment (Statement I) indicate that the practice on ɔble sown (dry) on 24th June or dibble sown in puddle on 6th August is as od as transplanting in the case of strain T-1242, while in the case of strain

T. 141 transplanting has given an increased yield of about 7 per cent over the other two treatments, which is, however, *not significant.*

This would indicate that in years when the rainfall is equitably distributed during the crop season, the practice of sowing (dry) or in puddle is as good as transplanting.

IV.—The effect of planting on different dates on yield

Four strains, *i.e.*, T. 141 and J. 192 in one field and T. 1242 and BAM-9 in another field, were planted on 7 different dates at 10 days interval, the first and the last date of planting being 28th July and 26th September, 1957, respectively. The results of the trial indicate that the July and 7th August plantings recorded the highest yield followed by 17th, and 27th August and 6th and 16th September plantings. It would be seen from the data that the strains T-141 and J.192 could be planted late up to 27th August unlike T-1242 and BAM-9 (though the yield of the late planted crop is reduced by about 15 per cent on an average as compared to July planting) and that the September plantings (6th and 16th gave poor yield—about half of July plantings in the case of the strains BAM-9 and T-1242.

The last planting *i.e.*, 26th September is virtually a failure. The particulars of the experiment are given in Statement II.

V.—N. P. K. Trial

A parallel experiment as conducted in the villagers' field in the intensive cultivation centre was laid out in the farm using T-141 strain with 6 replications, having the same 6 treatments as that of last year. The results of the trial indicate that the treatments namely (1) Nitrogen 45 lb. *plus* 60 lb. P_2O_5 per acre and (2) Nitrogen 30 lb. per acre recorded about 21 per cent more yield than the control " no manure ". The data are given in Statement III.

The above experiment was also carried out in the second crop season with the strain MTU-15. The results of the trial indicate that the treatment, *i.e.*, Nitrogen 45 lb. *plus* 60 lb. P_2O_5 per acre gave the highest yield, recording about 42 per cent more than the control " no manure ". The data are given in Statement III.

VI.—Second cropping of rice in the same field

An area of about 25 acres was cropped with rice during the year under report. After the removal of the " *aman* crop " the field was prepared and planted with two varieties MTU-15 and GEB-24 in the middle of January, 1958. The strains MTU-15 and GEB-24 gave an average acre yield of 18 and 15 mds. respectively.

VII.—Intensive Cultivation Centre

21 simple manurial trials with nitrogenous, phosphatic and potassic fertilizers were conducted in the cultivators, field. The results of the trial indicated that an increased yield of about 200 lbs. per acre was obtained in most of the trials. The data are presented in Statement IV.

STATEMENT I.

Treatments

1. Transplanting on 7th August, 1957.
2. Dibble sown dry on 24th June, 1957.
3. Dibble sown puddle on 6th August, 1957.

Results

Treatments	T_1	T_2	T_3	Mean
1. Variety T. 141	2934	2720	2741	2798
2. Variety T. 1242	3027	3076	2981	3028
	2980·5	2898	2861	

There is no significant difference between the different treatments as well as the two varieties T-141 and T-1242.

STATEMENT II.

Effect of Planting on different dates.

Varieties—4 Nos.

Time of Planting		
	T_1	28-7-57
	T_2	7-8-57
	T_3	17-8-57
	T_4	27-8-57
	T_5	6-9-57
	T_6	16-9-57
	T_7	26-9-57

Yield in lb. per acre

	T. 141	J. 192	T. 1242	BAM. 9
T_1	3525	3315	3767	3511
T_2	3608	3646	3278	3548
T_3	2716	3292	2892	3185
T_4	2776	3013	2511	2818
T_5	2232	2688	2497	1893
T_6	1920	2334	2004	1516
T_7	1209	1409	641	535

STATEMENT III.

N. P. K. Trial

(*Treatment*)

N_1	30 lb. N/Ac.
N_1P_1	30 lb. N *plus* 30 lb. P_2O_5/Ac.
N_2P_2	45 lb. N *plus* 45 lb. P_2O_5/Ac.
$N_1P_1K_1$	30 lb. N *plus* 30 lb. P_2O_5 *plus* 30 lb. K_2°Ac.
$N_2P_2K_2$	45 lb. N *plus* 45 lb. P_2O_5 *plus* 60 lb. K_2°/Ac.
Control (No manure)	

	N_1	N_1P_1	N_2P_2	$N_1P_1K_1$	$N_2P_2K_2$	Control (No manure)
Yield in lb. per acre	2719	2666	2741	2543	2539	2257
				C. D. (0·05)		318·56 lb.

II Crop. Variety MTU. 15.

(*Treatments : Same as in 1st crop*)

	N_1	N_1P_1	N_2P_2	$N_1P_1K_1$	$N_2P_2K_2$	Control (No manure)
Yield in lb. per acre	2142	2156	2208	2327	2273	1876
				C. D. (0·05)		255·7 lb.

STATEMENT IV.

N. P. K. Trial in Intensive Cultivation Centre : I Crop.

(*Treatments same as in Statement III*)

Treatment	N_1	N_1P_1	N_2P_2	$N_1P_1K_1$	$N_2P_2K_2$	Control (No manure)
Yield in lb. per acre	3008	3028	2995	3066	3040	3032
				C. D. (0·05)		363·2

TRAINING

1. *Post-graduate training course.*—Four 2nd year post-graduate students of the Indian Agricultural Research Institute's associateship course specialising in rice Agronomy joined the Institute for doing the thesis part of the course and worked on the following research problems.

1. Study of response of some *indica* and *japonica* types of rice to the various N and P levels in the *boro* crop season.
2. Study of the Response of *boro* rice to various types and levels of nitrogen in combination with phosphate and potash.
3. Effect of split application of nitrogenous fertilizers on the yield and other agronomic characters of rice (*Oryza sativa* L.)
4. Study of response of *indica* varieties of rice to different levels of soil fertility.

II. Three 2nd year post-graduate students of the Indian Agricultural Research Institute's associateship course specialising in rice botany joined the institute for doing the thesis, part of the course, and worked on the following research problems.

1 Mr. N. R. Nayar.—Genetics of Rice (*Oryza sativa* L). The inheritance of hairiness, clustering, beaked habit and anthocyanin pigmentation and the interrelationship of genes governing these characters.

2. Mr. G. A. Katwe.—Breeding rice strains suitable for different levels of. soil fertility—study of the F_4 generation of *japonica*×*indica* hybrids.

3. Mr. N. M. Nayar.—Studies on the origin of cultivated rice (*O. sativa* L). Cytogenetical studies of wild rice and hybrids.

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PROGRAMME OF WORK FOR 1958-59

Agronomy Division

1. Study of yield performance of different duration varieties.

2. Trial of varieties suitable for late *aman* planting and for double cropping.

3. To determine the suitability of various crops for growing in rotation with rice.

4. Study of the relative efficiency of various nitrogenous fertilizers.

5. Determination of the optimum dose, time and method of application of different nitrogenous fertilizers and their residual cumulative effect on soil fertility.

6. Study of the residual effect of organics and inorganics.

7. Study of the efficiency of various herbicides for control of weeds in the rice fields and to determine the optimum dosage and time of their application.

8. Study of the suitability of various green manure crops for rice and to determine their optimum time for sowing and incorporation in the soil.

9. Developmental studies in rice.

Botany Division

I. Maintenance and study of Genetic Stocks.

II. Improving yield by—

(*a*) Introduction -Preliminary yield trial of introductions in three trials.

(*b*) Selection—Bulk trial of secondary selections in Ch. 13 and Basmati rice.

(*c*) Hybridization -(*i*) Between *japonica—indica* varieties. Study of F_1, F_2, F_3, F_4, F_5, F_6, F_7 and F_8 generations in progeny yield trials and bulk trials.

(*ii*) Within *indica* group—Preliminary yield trial of homozygous cultures combining earliness, high yield and good grain characters.

III. Breeding for upland conditions—

(*a*) Preliminary yield trial of early-maturing introductions against the local standard.

(*b*) Second year trial of previous year's promising upland varieties.

(*c*) Trial of hill padies under upland conditions.

IV. Breeding for resistance to blast and *Helminthosporium*.

V. Breeding for high yield and profuse tillering.

VI. Breeding for high yield and good quality rice.

VII. Breeding for high yield and non-lodging habit.

(1) Agronomic practices in relation to lodging.

(2) Estimation of loss due to lodging.

(3) Varietal trial of lodging and non-lodging varieties.

(4) Trial of secondary selections from among non-lodging varieties.

(5) Trial of F_3 and F_4 cultures from crosses between lodging and non-lodging varieties.

(6) Anatomical studies in relation to lodging.

VIII. Breeding for good yield and non-photosensitivity.

IX. Studies on heterosis in rice.

X. Genetics.—

(*i*) Interrelationship between different dwarf genes, between genes for rudimentary auricle and those for the presence and absence of auricle, between different types of coloured leaf blades.

(*ii*) Inheritance of chlorophyll deficiencies.

(*iii*) Inheritance of anthocyanin pigmentation.

XI. *Cytology :* The research programme is on three topics—

(*a*) Normal and variant cytology of cultivated rice.

(*b*) Evolution and inter-relationships in the genus *Oryza* (*c*) Origin of cultivated rice and differentiation of subspecies.

The current year's work is—(*a*) Isolation and characterisation of aneuploid types of rice and use of X-ray treated seeds in securing structural variation in chromosomes. (*b*) Compilation of data on the species collection for preparation of a monograph. (*c*) Securing and studying true-breeding semisterile plants from progeny of *japonica*×*indica* hybrids and hybridization between geographical varieties of *O. perennis*.

XII. *Jeypore Botanical Survey Scheme.*—

(1) Study of the cultures raised from the collection of the third year for botanical and agronomical characters and perpetuation of material.

(2) Exploration and collection of material in—

(*a*) Adjoining areas of Bastar and Raipur districts of Madhya Pradesh.

(*b*) Adjoining areas of Kalahandi district of Orissa.

(3) Cytological examination of some of the wild types for chromosome number and other meiotic features leading to their genetic constitution.

(4) Examination of the material for grain characters.

Chemistry Division

I. Investigations on nutrient availability in water-logged soils and its relation to plant growth—

(*a*) Availability of nitrogen in soil with different fertilizer treatments and its relation to plant growth (continued from last year)—methods of soil and plant tissue tests to be studied.

(*b*) Study of ammonifying capacity of soil nitrogen and its relation to soil fertility (continued from last year).

(*c*) Influence of soil-water relationship on plant growth—effect of withholding irrigation water at flowering, on nutrient availability and crop yield.

II. Investigations on nutrient assimilation by rice plant.—

(*a*) Studies on *partial efficiency* of phosphate absorbed by rice plant in relation to time of application.

(*b*) Investigations on increasing fertilizer efficiency of different nitrogenous fertilizers like urea, ammonium nitrate and calcium ammonium nitrate.

(*c*) Investigations on the quality of transplant—influence of seedbed manuring on nutrient uptake and growth under field conditions.

(*d*) Growth and nutrient assimilation and its relation to grain yield of crop grown under nitrogen, phosphate and potash manuring (continued from last year).

Entomology Division

1. Study of varietal reactions of World Genetic stocks to pests in general and gallfly and stem borers in particular.

2. Studies on insect resistance in rice plant with special reference to gallfly and stem borers.

3. Efficacy of different methods of application of insecticides in controlling rice pests.

4. Estimation of loss due to gallfly and stem borers.

5. Insecticidal trials to control pests of rice.

6. Studies on seasonal abundance of pests with a view to forecasting outbreaks of major pests.

7. Studies on the influence of macro-and micro-climatic factors on the incidence of gallfly, leaf hoppers and stem borers.

8. Studies on the incidence of pests in relation to manuring.

9. Studies on alternate hosts of major pests of rice.

10. Collection of indegenous parasites and predators of the more important pests on rice with a view to utilizing them for biological control of pests on rice.

11. Studies on gall formation in rice.

12. Laboratory studies on bionamics of *Pachydiplosis, Schoenobius, Scirpophaga, Chilotraca sesamia* and *Leptocorisa*.

Mycology Division

1. Study and estimation of resistance to diseases in field of the collection of types under genetic stocks.

2. *Helminthosporium disease.*—

(*a*) Co-ordinated trial of selected resistant varieties in different states in India.

(*b*) Artificial infection tests on early types in genetic stocks for selection of resistant types.

(*c*) Breeding resistant types.

(*d*) Study on the nature of disease resistance of rice varieties.

3. *Blast disease.*—

(*a*) Co-ordinated trial of selected resistant varieties in different states in India.

(*b*) International co-operative trial on breeding for blast resistance.

(*c*) Artificial infection tests on early types in genetic stocks for selection of resistant types.

(*d*) Breeding resistance varieties.

(*e*) Study on the nature of disease resistance of rice varieties.

(*f*) Control of blast by spraying and dusting.

(*g*) Study on the nature of injury to rice plant due to spraying copper fungicides.

(*h*) Estimation of loss in yield due to blast.

(*i*) Effect of split application of N on blast incidence.

(*j*) Study of blast spores in air with the help of Hirst spore trap.

Statistics Division

1. Detail studies of fertilizers response, surface and growth curves.

2. Sampling for grain measurements and weight.

3. Study of inheritance of quantitative characters.

Farm Division

1. Multiplication of improved strains.

2. Maximisation of crop yield under the improved methods of cultivation.

3. Determining the effects of different dates of planting on the yield of rice crop.

4. Enlargement of extension work in the intensive cultivation centre.

STAFF

Director :	R. L. M. Ghose, M. Sc., F. A. Sc.

Agronomy Division

Agronomist :	Moti V. Vachhani, B. Ag., Ph. D.
Research Assistant :	M. S. Chaudhury, B. Sc., Assoc. I. A. R. I.
Research Assistant :	M. V. Rao, B.Sc. (Ag.).

Botany Division

Geneticist & Botanist :	R. L. M. Ghose, M. Sc., F. A. Sc.
Cytologist :	S. Sampath, M. A.
Assistant Botanist :	W. T. Butany, B. Sc. (Ag.) Hons., Assoc. I. A. R. I., M. S. (Texas).
Research Assistant :	R. K. Mishra, M. Sc.
Research Assistant :	R. Seetharaman, M. Sc.
Research Assistant :	K. S. Murty, M. Sc. (Ag.).
Research Assistant :	C. Gangadharan, M. Sc.
Research Assistant :	D. V. Seshu, M. Sc.

Chemistry Division

Agricultural Chemist :	C. T. Abichandani, M. Sc., Ph. D., A. R. I. C.
Research Assistant :	S. Patnaik, M. Sc.
Research Assistant :	R. R. Dutta, M.Sc.

Entomology Division

Entomologist :	P. Israel, M. A., F. R. E. S.
Research Assistant :	G. Vedamoorthy, B.Sc. (Hons.), M. A., Assoc. I. A. R. I.
Research Assistant :	Y. S. Rao, M.Sc.

Mycology Division

Mycologist :	S. Y. Padmanabhan, B. Sc. (Hons.) M. A., Assoc. I. A. R. I.
Research Officer Plant Pathology :	D. Ganguly, M.A., D.Phil.
Research Assistant :	C. S. Krishnamurty, B.Sc. (Ag.), Assoc. I. A. R. I.

Farm Division

Farm Superintendent :	M. S. Pillai, B. A., B. Sc. (Ag.).
Research Assistant :	C. N. Relwani, B. Sc. (Ag.).

Statistics Division

Statistician :	M. P. Jha, M. Sc.

II Five-Year Plan Scheme No. 1

Cooperation of Rice Research Between C. R. R. I. and Different Rice-Growing States.

Research Assistant (Class II Non-Gazetted) :	N. A. Parasuram, B. Sc (Ag.).
Do.	G. H. Chandwani, B. Sc. (Ag.).
Research Assistant (Class III) :	N. K. Chyau Patnaik, M. Sc.
Do.	M. V. S. Sastry, M. Sc.
Do.	J. Veera Raghavan, M. Sc.

I. C. A. R. Scheme for Further Research on Green Manuring Crops for Paddy.

Research Assistant :	P. Narasimha Rao, M. Sc.

I. C. A. R. Scheme for Survey and Collection of Breeding Material from Jeypore Tract of Orissa State.

Assistant Botanist :	S. Govindaswami, M. Sc., Ph. D.
Research Assistant :	A. Krishnamurty, M. Sc.

I. C. A. R. Scheme for Breeding Paddy Strains Resistant to Lodging.

Research Assistant :	M. J. B. Rao, M. Sc.
Research Assistant :	T. E. Srinivasan, M. Sc.

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